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GEOLOGISTS' ASSOCIATION

(FOUNDED 1858).

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G. S. SWEETING.

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PROCEEDINGS
OF THE
GEOLOGISTS' ASSOCIATION.

FRAGMENTS OF JET COAL IN THE CHALK OF KENT.

By L. HAWKES, D.Sc., F.G.S.

[*Received 26th February*, 1944.]
[*Read 4th November*, 1944.]

INTRODUCTION.

IN 1859, whilst tunnelling in the Upper Chalk (Senonian) at Lydden Hill, near Dover, workmen employed by the London, Chatham and Dover Railway came upon a mass of coal 4 cwt. in weight, about 4 to 10 inches thick, and 4 feet square. The coal contained " veins of ferruginous clay " and its immediate surround was chalk " strongly tinged with an iron-rusty colour." Specimens were examined by Godwin-Austen [7*], who compared them with British Oolitic coal. He argued that " its specific gravity precludes the supposition that it could have floated away of itself into the Cretaceous sea," and he concludes : " We may suppose that during the Cretaceous period some bituminous beds of the preceding Oolitic period lay so as to be covered by water near the sea-margin or along some river-bank, and from which portions could be raised off by ice and so drifted away, until the ice was no longer able to support its load." This suggestion of transport by ice was in accord with the explanation previously advanced for the occurrence of granite and other erratics in the Chalk [**8**], and later the Cambridge Greensand erratics were similarly accounted for [**19**]. A recent study of the Greensand erratics [**10**] having led me to reject the ice-transport hypothesis I became interested in the Lydden coal.

It is on record that a large fragment of the coal was to be presented to the Canterbury Museum, but it cannot now be traced. The specimens exhibited by Godwin-Austen in 1860 remained in the Geological Society Museum until 1911, when they were transferred to the Geological Survey.

Also in the Geological Survey repositories is a box of 20 specimens (Nos. 1366-1384) collected by W. Harris " from the Chalk of Charing, Kent." These are referred to by Godwin-Austen as including " some small specimens which have the appearance of being volcanic scoriae "[1] [**8**, p.255]. The two specimens which gave rise to this comment are coal, and as they throw light on the origin of the Lydden mass they will be described first.

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* For List of References see p 6.

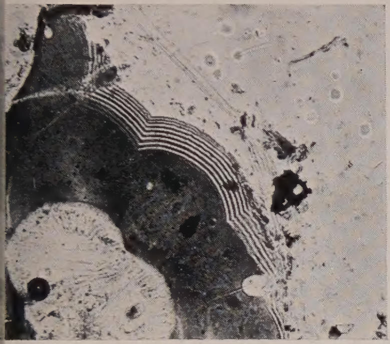
[1] This was a true but dangerous statement to make. As a result we find in the literature that volcanic scoriae are found in the Chalk [**14**].

THE CHARING COAL.

No. 1384 was a brown ball, 11 by 9 mm., with a rough exterior embedded in white Chalk. It consisted of a siliceous sheath enclosing loosely a round fragment of shiny coal 6.5 by 5.5. mm. The specimen was cut through the middle and a thin section prepared : this section is all that now remains of the specimen. The coal is for the most part opaque in section, but is transparent where especially thin, brown and isotropic. The sheath is largely built of quartz crystals having a tendency to radial distribution of the axes about the coal boundary and a similar orientation is shown about a coal fragment within the sheath. The quartz contains shreds of carbonaceous tissue.

In, and bordering the sheath, are spherules of clear chalcedony which are followed outwards in succession by broad zones of dark brown material, minutely banded zones of alternations of clear chalcedony and brown material, and finally fringes of quartz. The brown material has radial negative birefringence and is presumed to be chalcedony with carbonaceous matter. The bands of clear and brown chalcedony run parallel to the boundaries of the spherules (Pl. 1, Figs. 1 and 2.) The density of the banding in this zone increases outwards from about 200 to 600 pairs per millimetre. The quartz of the outer fringe exhibits a zoning due to groups of straight lines parallel to crystal faces (Pl. 1, Figs, 3, 4, 5.) The broader lines in this quartz are brown with carbonaceous matter. Storz has described a similar lineation in the quartz cement of a hematitic quartzitic sandstone from the Pomona district of S.W. Africa [**21**, p. 179]. He considers it to be due to rhythmic crystallization and observes that it is only found where an iron gel was present. We may similarly associate the zoning of the fringing quartz with the presence of carbonaceous gel. The photograph (Pl. 1, Fig. 3) of the banded chalcedony and zoned quartz compares closely with one given by Storz of a hematitic chalcedony-quartz succession [**21**, Taf. 1, 5]. The banding of the chalcedony is of Liesegang periodic type and may be due to diffusion into a gel, whereas the zoning of the fringing quartz appears to have resulted from periodic deposition on the growing quartz. Some of the spherules of brown chalcedony have opaque interiors and these, as Wetzel has suggested for similar spherules in silicified wood from the Holtenauer Canal [**25**, p. 43], probably represent bitumen drops.

No. 1370 is 2 cm. across, irregular in form, and consists of bits of coal with sheaths of silicified wood. The silicification is an infilling of the cells with quartz, the cell walls remain unaffected (*einkieselung*). Spherules of chalcedony with some quartzine and opal are surrounded by zoned quartz as in No. 1384, and there is some develop-



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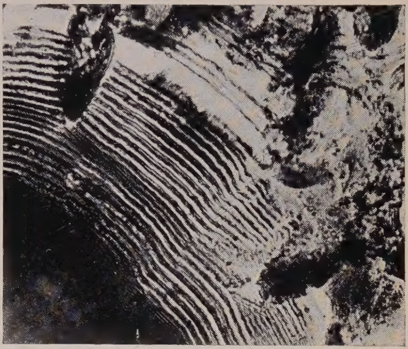

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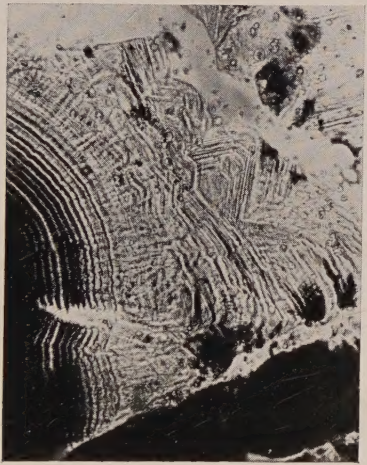

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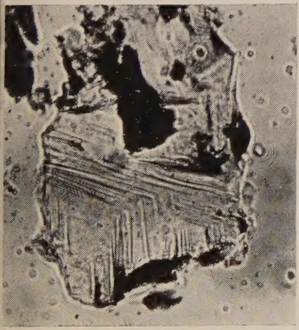

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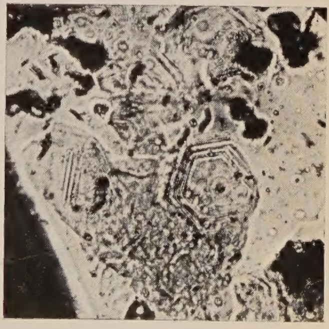

5.

BANDED STRUCTURES IN CHALCEDONY AND QUARTZ.

[*To face p*. 2.

ment of the Liesegang banding in the brown chalcedony. There is some interstitial Chalk.

Dr. R. Crookall kindly examined the thin section and he reports : " The more transparent parts are preserved cellular structure, chiefly parenchyma, but with a few woody cells. The more opaque parts are, of course, coal of the pitch-coal or vitrain type which was formed from wood or bark. I see no spores and no remains of leaves or miscellaneous plant debris. The specimen is part of a woody organ, probably part of a stem, and judging from the small diameter of the wood cells, a Coniferous stem, which has been more or less imperfectly coalified."

THE LYDDEN COAL.

The two specimens in the Geological Survey collections, Nos. 1358 and 1359, were respectively 9 and 8 cm. across. The coal, which burns freely with a yellow flame, is unbanded, black, shiny, and friable with a conchoidal fracture. There are cavities of irregular form lined with a yellowish brown powder of limonite, thin short seams of limonite, and double convex lens shaped cavities which are empty and clean. Some ' eenie ' fracture surfaces were observed and one clean cavity occupied the middle of an ' eye.' The original surface shows iridescence ; this, and the clean cavities probably result from the long storage of the specimens. Tiny quartz prisms occur with the limonite ; many carry inclusions of coal. Dr. Crookall examined the material for spores with a negative result.

The specimens were partly broken-up into small pieces and by hand-picking a sample as free from limonite as possible was prepared. I am indebted to the Director of the Fuel Research Station at East Greenwich for the following report on the sample :—

" Apparent specific gravity (ground coal), 1.094.

Proximate analysis (air-dried coal).

Moisture	2.5%
Volatile matter	58.9
" Fixed carbon "	38.0
Ash	0.6

Ultimate Analysis (dry coal).

Ash	0.6%
Carbon	76.0
Hydrogen	7.5
Nitrogen...	1.2
Sulphur (total)	7.1
Difference (oxygen and errors)	7.6

The coal showed very strong swelling property in the volatile matter test, the coke button filling the crucible."

The long storage of the specimens—86 years in open boxes—has probably resulted in some loss of carbon, hydrogen and sulphur, and some increase of oxygen [**23,** p. 40], but it is unlikely that these effects have been considerable, and in any case they only emphasize the special features of the analysis which are the high hydrogen and sulphur and low oxygen. Ignoring the moisture, ash and sulphur, the analysis is that of a typical cannel coal, and it also approximates to that of jet, as the following table shows :—

	Proximate (dry)			Ultimate (dry, ash, and sulphur free)			
	Volatiles	Fixed Carbon	Ash	C	H	N	O
Lydden coal	60.4	39.0	0.6	82.4	8.1	1.3	8.2
1. Cannel. Deep hard seam, Nottingham	56.9	37.4	5.7	82.7	7.3	1.3	8.7
2. Jet. Middle Lias, Whitby	61.8	35.1	3.1	84.2	6.6	1.1	8.1*
3. Jet. Whitby	76.2	23.3	0.5	84.9	7.7	1.1	6.3
4. Jet. Limits of seven analyses				82.3 — 84.3	6.0 — 7.6	0.8 — 1.1	7.1* — 9.4*

1. From Raistrick, A. and C. E. Marshall, "The Nature and Origin of Coal and Coal Seams." London. 1939, p. 210.
2. J. E. Hemingway, analyst. Personal communication.
3. Spielman, P. E. [20].
4. From published and unpublished analyses supplied by J. E. Hemingway.

Jet has long been classified with cannel coal and the chemical similarity of the organic matter of the two has been demonstrated by Thomas [24] and Spielman [20]. The Lydden specimen has not the toughness of the hard Whitby jet and the term 'jet coal' is to be preferred for it. The high content of 'organic sulphur' is notable. This is a feature shown by many coals which occur in immediate association with limestone or separated from it by only a thin layer of sediment [23, p. 287].

GENERAL DISCUSSION.

The specimens were found within 20 miles of each other, the physical characters of the three coals are the same, and it is assumed that they have the same origin. The absence of spores, the silicified wood of the sheaths of the Charing specimens, and the low ash content of the Lydden specimen all support the hypothesis that the original material was wood.

There can be little doubt that the infilling of the cells of the outer part of the Charing specimens with silica took place before the completion of the coalification of the interior with its destruction of the cell structure. Silicified wood is not uncommon in the Chalk and the silicification is most reasonably assumed to have taken place following the sinking of floating wood which had become waterlogged.[1] I adopt the same conclusion for the Kent coals—that partial silicification followed by jettification occurred in place. The brown chalcedony, the zoned quartz, and dense drops of the Charing specimens, are evidence of the production of bituminous matter—subsequently to the deposition of the silica of the cell infillings. It is unfortunate that none of the ' iron-rusty coloured Chalk ' surrounding the Lydden coal has been preserved : perhaps this was Chalk impregnated with bitumen. In essentials of nature, environment, and origin, the Kent jet coal compares closely with the Whitby jet with its accompanying liquid bitumen. It would be straining after an unnecessarily fortuitous and involved hypothesis to suppose that the specimens as they now are were formed in some earlier marine sediment, exhumed, and transferred in Chalk times by some exceptional means of transport.

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* Includes sulphur.

The process of coal formation is so little understood that it is not possible to say why the coalified wood is of jet rather than of lignite or brown coal composition—it falls outside the normal lignite to anthracite series. Gothan suggests that jet was formed from wood deposited in an oxygen free sediment [**9**], and the existence of an alkaline anaerobic environment may be postulated for the processes of reduction which have gone on. Stagnant anaerobic conditions would not in general be expected on the Chalk sea floor, although they may have obtained locally. Probably, however, the existence of such conditions after burial would suffice, and that they did exist in the Chalk is indicated by the presence in it of pyrite nodules. The nodules examined by Dr. Bannister contained no marcasite [**3**] and it is known that the deposition of iron sulphide as pyrite only, takes place under alkaline conditions [**1**]. Pyrite is present in the Whitby jet beds, and the limonite of the Lydden coal may have been derived from pyrite by oxidation. Janet has found wood enveloped by pyrite in the Chalk [**13**]. The high content of ' organic sulphur ' in the Lydden coal is of interest in this connection. Petrascheck observes that in the Ruhr and neighbouring areas the sulphur contents of the Carboniferous coals increase where the overlying rocks are marine, and he suggests this is due to the action of sulphur bacteria in reducing the sulphates of sea water [**18**].

The remains of drifted wood in the Chalk may be impressions only, or wholly silicified—sometimes adhering to or enclosed in flint, or friable carbonaceous matter " having the appearance as if it had been burnt " [**5**] and " of dark brown colour inclining to black —it falls into a carbonaceous powder upon exposure to the air." [**16**]. Apart from the Lydden occurrence the only reference to coal in the British Chalk is by Mantell, who states that " the more compact specimens have the appearance and texture of Bovey coal [**17**].

---

[1] The specific gravity of wood substance, if there is no great impregnation with resin or especially high mineral content, is about 1.56, being higher than that of coal substance [4]. Floating wood owes its buoyancy to the air it contains [15].

Petrification of wood blocks may take place from the inside or from the periphery and it is not clear what determines this [**22**]. Blocks of jet often contain wood petrified in silica [**11**] or in calcium carbonate [**12**], but the petrifactions are found in the middle of the blocks, whereas the silicification of the Charing wood is peripheral. Comparable with the Charing specimens are the stems in the Eocene Brown-Coal Formation of Gröbers near Hallé, with silicified peripheries and central parts " which can be cut by a knife, and burn when ignited [**6**]. Horn explains the incomplete petrifaction of the Spitsbergen jet blocks as resulting from compression of the outer unpetrified wood by overlying sediment, whereby circulation of solutions ceased and jetification began, but this explanation would not be applicable to the Charing specimens which were protected from compression by armouring sheaths.

Coal likened to jet and cannel is reported from several horizons in British Mesozoic strata and it would be interesting to know if this appelation is justified, but there appear to be no published analyses of the material. The closest parallel to the Kent Chalk coal, and which I mention last in order not to prejudice the above discussion, is found in the drift wood in the White Chalk (Senonian) of Lagerdorf. Holstein [**25**], p. 48. Some of this wood is silicified peripherally and encrusted with flint whilst the interior is " brown coal "—no analysis is available.

Dr. Bailey has written of the desert shores of the Franco-British Chalk Seas [**2**]. The abundant finds of fossil drift wood in the Chalk demonstrate that not all the shores were of this character.

Acknowledgments. I am indebted to the Director of the Geological Survey for permission to study the Kent specimens, to the Director of Fuel Research for the analysis of the Lydden coal, to Dr. R. Crookall for his examination of the material, to Dr. J. E. Hemingway for information regarding the Whitby jet, and as an evacuee I am grateful to Professor C. E. Tilley for the hospitality of the Department of Mineralogy and Petrology, Cambridge.

EXPLANATION OF PLATE 1.

Microphotos in ordinary light of section G.S. 1384.

1. × 80. Central clear chalcedony, broad zone of carbonaceous chalcedony, and outer zone of banded chalcedony.
2. × 160. Detail of zone of banded chalcedony.
3. × 160. Zoned quartz fringing the banded zone.
4. × 160. Zoned quartz.
5. × 160. Basal section of zoned quartz.

REFERENCES.

1. Allen, E. T. and J. L. Crenshaw. 1914. Effect of Temperature and Acidity in the Formation of Marcasite and Wurtzite. *Am. Jour. Sci.*, vol. clxxxviii, p. 394.
2. Bailey, E. B. 1924. The Desert Shores of the Chalk Seas. *Geo. Mag.*, vol. lxi, p. 102.
3. Bannister, F. A. 1932. The distinction of pyrite from marcasite in nodular growths. *Min. Mag.*, vol. xxiii, p. 186.

4. Büsgen, M., E. Münch and T. Thomson. 1929. The Structure and Life of Forest Trees. London. p. 192.
5. Dixon, F. and T. R. Jones. 1878. The Geology of Sussex. Brighton, p. 129.
6. Felix, J. 1894. Untersuchungen über fossile Hölzer. *Zeits. d. Deut. geol. Ges.* vol. xlvi, pp. 80-81.
7. Godwin-Austen, R. 1860. On the Occurrence of mass of Coal in the Chalk of Kent. *Quart. Journ. Geol. Soc.*, vol. xvi, p. 326.
8. ———. 1858. On a Boulder of Granite found in the "White Chalk" near Croydon, and on the Extraneous Rocks from that Formation. *Quart. Journ, Geol. Soc.*, vol. xiv, p. 252.
9. Gothan, W. 1906. Über die Entstehung von Gagat und damit Zusammenhängendes. *Naturwiss. Wochenschr*, vol. xxi, p. 17.
10. Hawkes, L. 1943. The Erratics of the Cambridge Greensand, their nature, provenance, and mode of transport. *Quart. Journ. Geol. Soc.*, vol. xcix, p. 93.
11. Hemingway, J. E. 1934. The Lias of the Yorkshire Coast. *Proc. Geol. Assoc.*, vol. xlv, p. 256.
12. Horn, G. 1929. Über Gagatartige Kohle aus Spitsbergen. *Norsk. Geol. Tids.* vol. x, p. 213.
13. Janet, C. 1891. Note sur les conditions dans lesquelles s'est effectué le depot de la Craie dans le bassin Anglo-Parisien. *Bull. de la Soc. Géol. de France*, vol. xix, p. 904.
14. Jones, T. R. 1886. The Origin and Constitution of Chalk and Flint, etc. *Trans. Herts. Nat. Hist. Soc.*, vol. iii, p. 147.
15. Lyell, C. 1832. Principles of Geology, vol. ii, p. 240. London.
16. Mantell, G. 1822. The Fossils of the South Downs. London. p. 102.
17. ———. 1833. The Geology of the South-East of England. London. p. 96.
18. Petrascheck, W. 1931. Das Vorkommen der Kohlen. *Handbuch der Mineralchemie*, C. Doelter u. H. Leitmeier. Bd. iv, t. 3, pp. 560-562.
19. Sollas, W. J. and A. J. Jukes-Browne. 1873. On the Included Rock-Fragments of the Cambridge Upper Greensand. *Quart. Journ. Geol. Soc.*, vol. xxix, p. 11.
20. Spielman, P. E. 1908. On the Origin of Jet. *Chem. News*, vol. xcvii, p.181.
21. Storz, M. 1928 and 1931. Die secundäre authigene Kieselsäure in ihrer petrogenetisch-geologischen Bedeutung. Berlin.
22. Stromer, E., H. Kraut and M. Storz. 1933. Der Erhaltungszustand und die Entstehung der Kieselhölzer Agyptens." Abh. d. Bayer. Akad. d. Wiss, Math.-naturwiss. Abt, H., vol. xvi, p. 9.
23. Stutzer, O, and A. C. Noe. 1940. Geology of Coal. Chicago, p. 252.
24. Thomas, J. W. 1876. On the Gases enclosed in Cannel Coals and in Jet. *Chem. News,* vol. xxxiii, p. 218.
25. Wetzel, W. 1913. Über ein Kieselholzgeschiebe mit Teredonen aus den Holtenauer Kanal-Aufschlüssen. *Sechster Jber. d. Niedersäch. geol.* Ver. Hanover, p. 20.

DISCUSSION.

Dr. E. Dix said that she was much interested in the work which Dr. Hawkes had carried out in this problem of the origin of coal in Chalk. Recently she had investigated some lignite found in the Wadhurst Clay, Neocomian Series, Tonbridge, Kent. It was significant that the chemical analysis of this specimen worked out by Dr. G. W. Himus was markedly different from that of the jet coal in Chalk described by Dr. Hawkes. The ultimate analysis of the lignite is as follows :—

Moisture	11.3%
Carbon	58.35
Hydrogen	4.35
Sulphur	.95
Oxygen, Nitrogen and errors by difference	16.00
Ash	9.05

The carbon and sulphur content of the lignite was considerably lower than that of the jet coal.

The lignite represented a branch of a conifer deposited in sandy muds of freshwater origin and it is probable as suggested by Dr. Hawkes that the peculiar chemical composition of the jet coal can be explained by the fact that coalification took place under marine conditions.

She stated that she had applied Schultz solution to specimens of hard jet from Whitby, kindly lent by Dr. Hemingway and to the lignite from the Neocomian Series with varying results. In the case of the lignite detailed plant structure could be seen after a period of 12 hours in the acid, while structures of the wood in the hard jet were revealed only after immersion in the acid for from two to three days.

Mr. T. Eastwood drew attention to certain similarities of the region under discussion with that of Whitby described in the Geological Survey Memoir by Fox Strangways. There the jet is in lenticular masses amidst marine strata and there, too, Fox Strangways attributed the deposits to coniferous wood drifting in the sea of that period until it became waterlogged and sank. One supposed that the sunken timber ultimately became jelly-like and a mass of it was prevented from spreading as a film on the sea floor by some antagonism between it and sea water akin to that of grease and water.

Dr. G. M. Lees said that the woody texture discovered in the small-pea size occurrence at Charing could not be used as indubitable evidence for the nature of the large mass of "coal" of Lydden Hill; nor was the analysis conclusive. He suggested that the Lydden Hill material might be a bitumen which had floated into the Chalk sea from a source somewhere to the north and had later sunk perhaps as a result of slight increase in specific gravity due to gradual inspissation. The analysis provided by Dr. Hawkes could be matched by that of many known bitumens or asphaltites, some of which may be infusible and even insoluble in ordinary solvents. He quoted, for example, a deposit in Cuba ("Asphlat and Allied Substances," Abraham, p. 255) occurring as an intrusive vein in limestone which had the following composition :—

	Magdalana Mine.	La Habana Mine.
Carbon	72.5 to 77.8%	82.5%
Hydrogen	8.5 ,, 8.7	7.5
Sulphur	6.9 ,, 7.7	6.4
Difference ...	6.6 ,, 11.4	3.6
S.G.	1.45 ,, 1.49	1.175

Dr. K. P. Oakley said that Dr. Hawkes' most interesting paper had an indirect bearing on problems connected with flint.

The occurrence of a flint casing round some of the siliceous logs of wood recorded in the Chalk near Kiel was consistent with the theory that flint was epigenetic in relation to Chalk rather than syngenetic.

Dr. Hawkes' suggestion that jetification of wood required an alkaline environment reminded one that the replacement of Chalk by silica was generally regarded as a process entailing the formation of calcium bicarbonate (weak alkali). The complete de-opalization of the flint pebbles in the Blackheath Beds at Knockmill, however, had been attributed to the action of circulating water containing sodium carbonate (perhaps a result of base-exchange). The thick zone of de-opalization (i.e., the friable white cortex) shown by many flint nodules within the Chalk possibly recorded the passage, at some stage of water with this stronger alkalinity.

The author's reference in his description of the Charing nodules to the "diffusion of oily matter into the silica-gel" suggested a possible solution to a minor problem of flint which had long puzzled the speaker. Flint appeared to be an epignetic replacement of pure Chalk, yet it was said that its dusky pigmentation was partly due to traces of carbonaceous matter (although there was a regrettable lack of published analyses of English flint). On being struck flint threw off incandescent particles which gave rise to a smell of burning horn; a smell reminiscent of that produced by breaking certain types of bituminous limestone. Was this smell due to some inorganic gas produced in association with the triboluminescence, or was it connected with the combustion of traces of hydrocarbon released from the flint ? It did not seem unlikely that the Chalk as deposited was to some extent bituminous (and therefore, incidentally, not nearly so white as it now appears). Chalk consists in large measure of microscopic "spheres," not unreasonably interpreted by some as the calcareous coatings of unicellular plants. The decomposition of this planktonic material—if such it was—under conditions which allowed the jetification of coal, might be expected to have given rise to some oily matter. Any oil there may have been in the Chalk has, of course, long since oxidised away ; but traces still present when flint was in its formative, gelatinous state would surely have diffused into the latter (just as iron solutions did). Perhaps only under exceptional conditions would the diffusion show the Liesegang-effect. At any rate, with the hardening and crystallization of the silica-gel any diffused hydrocarbons would have become permanently fixed in the substance of the flint. It is noteworthy in this connection that the later generations of flint tend to be more lightly pigmented than the primary generation.

MR. P. A. SABINE : Among many interesting points raised in Dr. Hawkes' paper was that of the origin of banded chalcedony, to which Dr. K. P. Oakley drew further attention. Dr. Oakley suggested that in an analogous manner flint had been formed by the carbonaceous matter from plant material present in the sediment precipitating the silica. Comparison may be drawn here with carbon and gold in the Rand Banket. In these African deposits, Dr. M. S. Fisher has shown (*Trans. Inst. M.M.*, 1939, p. 495) that where banket contains carbon, gold is so frequently of high tenor that the carbon may in most cases be taken as a test for high gold values. Dr. Fisher also stated that the gold may be shown by mineragraphy to be near or in the carbon which occurs as nodules, and deduced that precipitation of the gold was facilitated by the presence, amongst other things, of "carbon when available." Strong evidence is available for the carbon being carried by epigenetic hydrothermal solutions, whilst the precipitated gold is usually found to replace quartz.

If this holds for carbon and gold, it seems possible that since carbon and silicon are chemically closely related, a similar state may exist between silicon and carbon or carbonaceous matter. Whilst gold is admittedly somewhat remote from the formation of chalcedony, a tentative comparison may thus be justified ; if it is, then this comparison again accords with the concept that flint is a replacement deposit.

THE AUTHOR : Dr. Lees suggests a mode of origin for the Lydden coal which had not occurred to me. The specimens which have been preserved do not include any silicified parts, and Dr. Lee's hypothesis must stand as a possibility. In view of the abundance in the Chalk of similar coal which had demonstrably been formed from wood, the Author would consider himself badly treated by Nature if she had dropped amongst the other specimens such an oddity as a bitumen raft.

ANNUAL REUNION.

WITH EXHIBITS AND DEMONSTRATIONS HELD AT KING'S COLLEGE, STRAND, W.C., ON 3rd JUNE, 1944.

THE third reunion of the Association was held, by the courtesy of the Delegacy, in the Geological Department, King's College, Strand, W.C.2, on Saturday, 3rd June. Professor W. T. Gordon acted as convener, and arranged accommodation. It had been assumed, on the basis of the former war-time meetings, that about 100 members and friends would probably attend, and the exhibits were therefore arranged in three rooms, on two floors of the department, so that there would not be any uncomfortable congestion. Actually some 150 members and friends were present, but the rooms proved adequate to the occasion, though tea had to be arranged in relays. Students of the College took over the serving of tea, and visiting students from Imperial College lent a hand in serving.

In welcoming the President and members, Professor Gordon stated that he, Dr. Wells, and the students were delighted to welcome the Association once more to the laboratories. The former occasions had been classed with the Excursions, and, therefore, entirely departmental, but on this occasion exhibits had been arranged by some 25 members.

Each exhibit was described in general terms to the company, from the rostrum, and then demonstrated in greater detail, to those specially interested by a more intimate examination of the specimens.

After tea, which was served at 5 p.m., the President moved votes of thanks to the Delegacy of King's College, to Professor Gordon, to Dr. Wells, to the Exhibitors and to the students who had been responsible for serving the tea. Professor Gordon was also asked to convey special thanks to his niece, Miss Mary Davidson. The meeting, in the opinion expressed by many members, was most interesting and enjoyable.

1. PHOTOGRAPHS OF THE ERUPTION OF VESUVIUS, 1944.

Exhibited by Major D. C. BAILEY, (per Dr. E. B. Bailey, F.R.S.)

2. FINE MINERALS AND MINERAL CRYSTALS ; METAMORPHIC ROCKS.

Exhibited by E. P. BOTTLEY and Mrs. BOTTLEY.

3. SPECIMENS OF LAVA, ERUPTED FROM VESUVIUS, 1944.

Exhibited by C. N. BROMEHEAD, B.A.

4. NATURAL AND ARTIFICIAL MOULDS OF MOLLUSCAN SHELLS FROM THE DEPARTMENT OF GEOLOGY, BRITISH MUSEUM (NATURAL HISTORY)

Exhibited by L. R. COX, Sc.D.

The calcareous tests of mollusca and other organisms frequently disappear by solution in fossilization and the palaeontologist is faced with the problem of determining material preserved in the form of moulds. The desirability of collecting external moulds (when clearly preserved) as well as internal moulds is obvious, but the latter, being obtainable with much less difficulty, are often the only material sent for study. In the case of thin shells (e.g., *Pholadomya*, *Clementia*) the internal mould may bear a fairly clear impression of the external ornamentation and accurate determination is not difficult. With thicker shells (e.g., *Trigonia* and most gastropods) the external ornamentation is not impressed on to the internal mould, and this may often differ very much from the original shell in appearance. In a few gastropods (e.g.,*Campanile*, *Nerinea*) the internal mould has its own peculiar ornamental features, due to the presence of varices, spiral folds or rows of tubercles on the inside of the shell. Internal moulds of the lamellibranchia, especially when the valves are isolated or displaced, may bear the impression of internal characters, such as the dentition, muscle scars and pallial line, which are of great help in generic determination, and such material is particularly useful when contemporaneous deposits yield well-preserved shells whose interiors are not exposable by development. Usually, however, internal moulds of lamellibranchs are of specimens whose valves became closed again after the decay of the soft parts ; such specimens bear the impressions only of the distal ends of the interlocking hinge-teeth, so that a detailed reconstruction of the dentition is not possible from their study.

The material exhibited included series of specimens from various formations (the Northampton Ironstone, the Portland Stone, the Eocene of the Kressenberg (Bavaria), the Eocene and Miocene of Egypt, and the Pliocene of the Mekran coast of Baluchistan) in which molluscan fossils occur mainly as moulds. With them was exhibited a series of internal moulds of Eocene and Recent shells prepared artificially and showing that specific as well as generic differences are definable in such material. The study of these artificial moulds had facilitated the determination of specimens from the Eocene of India, the Miocene and Pliocene of East Africa, and other formations. Plaster moulds exhibited were of interest as belonging to a series distributed in 1839 by L. Agassiz, who had partly described them in a paper entitled " Memoire sur les moules de mollusques vivans et fossiles " (*Mém. Soc. Sci. nat. Neuchatel*, vol. ii, 1839). The majority of these were reproductions of internal moulds made by filling the actual shells with a molten alloy (D'Arcet's Metal) of low melting point, subsequently dissolving away the shell with acid. A mould of a *Helix* shell prepared by the exhibitor in " Wood's Alloy " (a comparable alloy) was also shown, together with a series made in paraffin wax by a similar process.

5. LIGNITE FROM THE WADHURST CLAY, WEALDEN SERIES (NEOCOMIAN), KENT.

Exhibited by Miss EMILY DIX, D.Sc.

The specimen from the Wadhurst Clay, Quarry Hill Brickfield, Tonbridge, Kent, was kindly supplied by Mr. G. S. Sweeting. It was about 3 inches in length, and 1.2 inches in diameter, and it obviously represents an incomplete portion of a stem. Its woody character is clearly apparent in hand-specimen. In some respects it resembles cannel coal with its dull and sometimes pitchlike lustre, and its conchoidal fracture which is well developed in a small pattern in a longitudinal direction. Traces of extraneous mineral matter can be seen on the joint planes. Its specific gravity is 1.7.

A portion of the lignite was treated with Schultz' solution (nitric acid and potassium chlorate) for 12 hours and then washed and dried. As a result, the character of the lignite became clearly visible, resembling the wood of a portion of a modern twig. Fragments were mounted in Canada balsam, when the arrangement of bordered pits in the tracheids could be seen under the microscope. Specimens, after treatment in the Schultz' solution, were macerated and then stained with Bismark brown and mounted in glycerine jelly. Several tracheids could be seen, some of which showed uniserial bordered pits characteristic of the *Abietineae*.

A sample was analysed by Dr. G. W. Himus with the following results :—

PROXIMATE ANALYSIS.

	Per cent.
Moisture	13.55
Volatiles	40.3
Fixed Carbon	38.8
Ash	7.35

ULTIMATE ANALYSIS.

	Per cent.
Moisture	11.3
Carbon	58.35
Hydrogen	4.35
Sulphur	0.95
Oxygen, Nitrogen and errors	16.00

Dr. Himus adds that the composition agrees with that of other lignites from the Cretaceous System. Moore [1] gives the average analysis of lignite or brown coal as :—

> Moisture, 14.42 ; Volatiles 40.78 ; Fixed Carbon 36.37 ; Ash 9.32 and Sulphur, 1.14 per cent. Carbon 58.14 ; Hydrogen 5.14 ; Nitrogen 1.05 and Oxygen 25.17 per cent.

It is interesting to note from his analysis the close similarity in the carbon, ash, hydrogen and sulphur of these lignites with the specimen exhibited from the Wadhurst Clay. Dr. Himus states that there was little clayey matter in the ash, but a good deal of lime, probably present originally as calcium carbonate. It is probable that a considerable portion of the ash was derived from the actual plant.

Other traces of plant remains occur in the Wadhurst Clay at this locality. It appears that the lignite was derived from a branch of a conifer deposited in sandy muds of freshwater origin reflecting physical conditions characteristic of the Carboniferous freshwater lagoons. There appears to be no evidence of compression of the original wood in its conversion into lignite and the tissues must have been permeated, shortly after burial in the mud, by a humic substance derived from decaying plant remains. The references to the occurrence of jet in Neocomian rocks of the Weald and in the Isle of Wight [2] require further investigation. Dixon [3] states " In the Wealden at Brook, Isle of Wight, numerous cones of *Cycadeae* occur. They are converted into jet, and are largely charged with iron pyrites so that it is difficult to preserve them or to examine their structure minutely." It is possible that all the above references to jet should be referred to lignite. The carbon content of jet is considerably higher than that of lignite. (Moore [**1**].) The question of the origin and chemical composition of jet is being investigated by Dr. Hemingway and Dr. Hawkes [**4**].

REFERENCES.

1. Moore, E. S. Coal. John Wiley and Sons. 1940.
2. White, H. J. Osborne. 1921. A Short Account of the Geology of the Isle of Wight. *Mem. Geol. Survey*,
3. Dixon, F. 1878. Geology of Sussex.
4. Hawkes, L. 1945. Fragments of Jet Coal in the Chalk of Kent. *Proc. Geol. Assoc.*, vol. lvi, pp. 1–9.

6. A. DIAGRAMS OF SPRING-PITS AT FETCHAM MILL-POND.

B. MAP OF THE MOLE VALLEY SHOWING SWALLOW-HOLES.

Exhibited by F. H. EDMUNDS, B.A.

Mr. Edmunds gave a short talk explaining the diagrams and inviting discussion on the phenomena illustrated.

7. THE GEOLOGY OF OPEN-CAST MINING OF COAL AND IRONSTONE.

Exhibited by W. D. EVANS, D.Sc.

Dr. Evans described some of the salient features of this development in War Industries.

8. GEOLOGICAL AND TOPOGRAPHICAL MAPS OF THE IMPHAL AND KOHIMA DISTRICTS OF ASSAM.

Exhibited by PERCY EVANS, M.A.

Mr. Evans exhibited geological and topographical maps and geological sections of the country near Kohima and Imphal, where the Assam fighting has been taking place, and drew attention to the close connection between geology and the course of the military operations. A thick shale series is overlain by a thick sandstone series and both have been folded and faulted. The sandstones in the synclines determine the high ground and the shales along the anticlinal axes form the lower ground. South-west of Kohima are the high ranges of the Kohima syncline and immediately east comes an anticline along which runs the road to Imphal. The Manipur Plain lies on the broad shale outcrop produced by the convergence of several anticlines near Imphal ; many of the surrounding hills (which rise to 5,000 feet above the plain) are made up of the overlying sandstones, and north-east of Kohima the sandstone outliers of another syncline form high hills. The structure has determined the distribution of the sandstone and shale groups, and this in turn has controlled the type of country and the lines of communication, and hence the military objectives and the lines of attack.

9. INDUSTRIAL DIAMONDS AND SOME INTERESTING AND UNUSUAL DIAMOND CRYSTALS AND SPECIMENS.

Exhibited by Professor W. T. GORDON, M.A., D.Sc.

Three distinct points had been kept in view in arranging the exhibit. Firstly, to show specimens illustrating the occurrence of the mineral in nature ; secondly, to have on exhibition some interesting crystal habits of diamond, some common, some quite uncommon ; and thirdly, a series of the actual tools in which diamond was the operating material.

Most diamond crystals have minute cracks, and even impurities, enclosed in them, so that careful selection was necessary to secure suitable crystals for great precision work. The name bort, or boart, had been given to this material. In the past the crystals that had many cracks were broken up into abrasive powder, and used in fabricating other diamonds or various hard substances. Crystals that enclosed impurities could, if otherwise sound, be employed in drilling operations or as truing tools. But there had accumulated a great deal of what was termed "crushing boart." A recent invention, however, had shown how this material could be utilised, and several specimens of diamond and metal powder, "tipped" tools were shown. The operative parts, in each case, had been formed from a mixture of metal powder and diamond powder in pre-arranged proportions, and pre-arranged sizes of diamond powder according to the results of definite researches. The mixed powders were heated, in contact with a "blank" as holder, to such a temperature that the application of pressure induced a welding action among the metal grains, which, consequently, enclosed the diamond grains uniformly and tightly in a kind of metal sponge. To ensure close contact between the diamond and the metal, the diamond grains were sometimes coated with a metal, precipitated chemically on their surfaces. Thus a film of metal alloy was formed round each grain, and closer contact effected. Specimens of several grades of diamond powder, coated and uncoated, were shown.

Prof. Gordon then referred to other types of tools where natural crystals of diamond might be used without fabrication. Such were truing tools for emery, carborundum and other abrasive wheels, glass cutters, saw blades, either circular or straight, and drilling bits. For the latter the special kind of diamond, carbonate, was preferred. But that was expensive, and diamond powder bits had recently proved very successful. One was shown that had had a long life in boring into granite. The particular bit had been used under controlled laboratory tests, certainly, but there were distinct possibilities for bits of this kind to be used in making shot-holes for blasting operations. He stated that this actual crown had bored several hundred feet, all told, into Cornish granite—a sample of the core was on exhibit—at a rate of about 9 inches per minute.

Fabricated diamond tools were then noted. Writing diamonds, engraving points, testing devices for hardness of metals, wire drawing dies and various shaped turning tools were described. He referred specially to the high quality of the diamond that had recently been employed for such tools when great precision was required. When precision turning was necessary, involving correctness to 1-16,000 part of an inch, only a diamond cutting edge was sufficiently durable for any length of time. Minute flaws or inclusions of impurities would adversely affect such an edge, and, consequently, finer and finer qualities of diamonds have been demanded in the industrial series. Much diamond, formerly used for decorative gems, was being transferred to industrial purposes, such as wire drawing dies, and precision tools for direct or indirect operations on metals or plastic materials.

Professor Gordon also showed a number of interesting natural diamond crystals. Among them were several well-shaped octahedrons of fine quality material. These came from different localities —Wesselton, Sierra Leone, Angola and Kimberley. Cubic crystals from Bas Congo Katanga and Sierra Leone and a tetrahedron from British Guiana.

Distorted growth forms of the octahedron were displayed, some were merely flattened slightly, but very thin platey crystals, elongated prismatic growths (really octahedrons), a series of interpenetrating octahedrons, hollow crystals, crystals with holes right through them, and fibrous radiating aggregates called " ballas " or " ball-boart " were all exemplified by selected specimens. A very good example of an octahedron crystal with an exactly parallel octahedral cavity, and one of the curious " hailstone " boart, completed the detached crystal exhibit.

Lastly, examples of diamonds in the matrix from Barkly West, Dutoitspan, Kimberley, Namaqualand, Sierra Leone and Diamantina, Brazil indicated that the real source rock of diamond has not been found yet, unless eclogite (a specimen of which, containing diamond, was shown) by the parent rock.

The geological age of diamond deposits was mentioned. One crystal from the gold-bearing conglomerates of South Africa, and therefore definitely of Pre-Cambrian age, was on exhibit, those in the Kimberlite from Kimberley are as definitely of Post-Cretaceous age. Examples from sedimentary rocks of Eocene and Recent deposits cannot be dated exactly, for they have been derived from earlier rocks by disintegration, and subsequently enclosed in later sediments. Whether they were all actually formed at one period of the earth's history, and brought to the surface at different times, through the operating of volcanic processes, is still uncertain. Equally uncertain are the conditions which might produce diamonds in the laboratory. But some method of artificial production in bulk will have to be discovered if the present use of diamond in industry is to be extended or even continued during the next half century. New sources of natural diamonds may be discovered, of course, but, unless they are, the industrial situation may become difficult.

10. A. CLAY IRONSTONE NODULES FROM THE ATHERFIELD CLAY CONTAINING ZINC SULPHIDE (SPHALERITE).

B. *PARAHOPLITES NUTFIELDENSIS*, SPATH, PHOSPHATIZED SPECIMENS, FROM THE BARGATE STONE HORIZON, MIDHURST.

Exhibited by A. H. GUNNER, F.G.S.

11. USES OF POLAROID AS A SUBSTITUTE FOR NICOL PRISMS.

Exhibited by A. F. HALLIMOND, M.A., Sc.D.

12. METAMORPHOSED VOLCANIC ROCKS FROM ANZIO, ITALY.

Exhibited by R. J. KING.

13. SCOTTISH COMMERCIAL MICA.

Exhibited by M. MACGREGOR, M.A., D.Sc.

14. NON-MARINE LAMELLIBRANCHS FROM NORTH STAFFORD COALFIELD.

Exhibited by R. V. MELVILLE.

15. " FOSSIL " SPRING-PITS FROM THE CAMBRIAN ROCKS OF THE WREKIN. DIAGRAMS, etc.

Exhibit by R. W. POCOCK, D.Sc.

16. TYPICAL MINERALS FROM THE ANHYDRITE MINE OF THE IMPERIAL CHEMICALS INDUSTRIES, LIMITED, AT BILLINGHAM, CO. DURHAM.

Exhibited by A. E. V. VICKERS, M.Sc., Ph.D., and D. G. A. WHITTEN, B.Sc.

17. PHOTOMICROGRAPHS OF ROCK-FORMING MINERALS.

Exhibited by A. V. WEATHERHEAD.

The photomicrographs displayed were negative enlargements of rock-forming minerals, as seen in thin section in transmitted light, at magnifications from eighteen to twelve hundred diameters. A horizontal long extension plate camera was employed in conjunction with a petrological microscope, illustrated by a line diagram, the negatives being prepared on 4¼″ x 3¼″ and 3½″ x 2½″ photographic plates.

Cross-nicol effects were beautifully portrayed, and one outstanding example was that of a fine leucite crystal showing the four twin planes and the characteristic " organ pipe " structure. A number of minerals were shown in both transverse and vertical section, while a crystal of tourmaline and the radiate acicular schorl were impressive reproductions.

These enlargements were selected from a set prepared by the exhibitor for teaching purposes and museum display. With this object in view a bromide paper having a smooth-matt surface finish was chosen to obviate undesirable reflections when used for demonstration in class work.

18. A. SANDS AND GRAVELS OF SPECIAL TYPES.

B. COLLECTIONS OF PEBBLES TO SHOW THE INFLUENCE OF ENVIRONMENT ON SHAPE.

Exhibited by A. K. WELLS, D.Sc.

The first exhibit included monazite-sand and garnet-sand, both fairly pure concentrates, and an olivine-ilmenite-sand from Jan Mayen. An olivine-augite-sand collected by Professor S. H. Reynolds from a locality in Hawaii is a particularly beautiful natural concentrate of very small, perfectly euhedral olivine crystals, sharp-edged and quite unworn. Associated with the olivines are augites, fewer in number, but equally perfect in form, occurring as simple crystals, twins and twinned aggregates, all unworn and with lustrous faces. These are quite the best augite crystals the exhibitor has seen.

In material of larger grain-size, various samples were shown of gravels consisting largely of agates, chalcedony, jasper, onyx and other forms of silica. These were collected from two different localities : from the Vaal River Gravels in the neighbourhood of Beaufort West, and from the Pomona district in S.W. Africa.

A similar deposit of quite exceptional beauty was represented by a Challenger Expedition sample, in Prof. Gordon's collection, of a very coarse sand from " Hotentot Bay " S.W. Africa. Like the much coarser gravels mentioned above, this also consists almost exclusively of tiny agates and variously coloured chalcedonies, rolled to a regular spheroidal form, and with a brilliant vitreous lustre as if polished by a lapidary. This sand and the olivine-augite-sand noted above, make attractive objects using the binocular microscope.

A gem-gravel from Ceylon was shown, together with various gem-minerals isolated from it, notably numbers of good octahedral crystals of spinel, ranging from the rich blood-red of ruby-spinel, through pinks to anaemic crystals almost without pigment.

Among the collections of pebbles shaped in different environments were ventifacts (dreikanters) from the Pomona gravels flooring the Namib Desert, S.W. Africa. These are so symmetrical in form and so perfectly finished, that many people have difficulty in believing that they have been shaped by natural agents—they certainly would pass as pygmy implements. Many of these, again, consist of silica in one form or another, but others are of fine-grained igneous rock, "felsite," basalt and lamprophyre. Another small collection included pebbles of quartzite and vein-quartz, facetted and striated by ice, from a fossil tillite high up on Table Mountain, in the Table Mt. Sandstone.

For contrast, flattened ovoids of quartzite from a fluvial gravel occurring at about 400-feet O.D., in Aberdeenshire ; near-spheres of granite, schists and gneisses of various types from shore gravels near Stonehaven ; and the sun-chipped quartzites from the Keuper of the Charnwood area—Dr. Raw's insoliliths—were exhibited.

19. SPECIMENS FROM THE LIAS OF OXFORDSHIRE.

Exhibited by T. H. WHITEHEAD, M.Sc., A.R.C.S.

20. A RAPID METHOD OF MAKING ACCURATE DRAWINGS OF SMALL AND MICROSCOPIC OBJECTS.

Exhibited by ALAN WOOD, Ph.D.

Accurate line drawings are very useful in certain types of research, being often better than photographs, since extraneous detail can be omitted. The following method has been developed for drawing foraminifera, but it is applicable to a large number of subjects.

Briefly, the apparatus consists of a box with one side covered with a sheet of clear glass, and the opposite side having a hole to fit over the top of a microscope. The image of the object is projected upwards on to a sheet of Kodatrace (a proprietary celluloid tracing material which gives a very clear image) placed on top of the glass. The image can then be traced, and, by changing the lenses, any desired magnification can be obtained. The principle is the same as in an old-fashioned camera, when the image was projected on to a focussing screen of ground glass at the back, but here the ground glass is replaced by the removable tracing celluloid. One great advantage of this method is that the focussing screws of the microscope may be used when drawing, so that the image seen may be investigated in three dimensions.

By using a camera with the lens removed fitting on top of the microscope it is possible to alter the magnification by lengthening the bellows, but a box device, as just described, works perfectly well.

Obviously the usefulness of this method is not restricted to palaeontology alone. Sketches of rock sections, showing the relationship of one mineral to another, and in fact of any transparent microscopic object, may be made with equal facility.

The same principle may be applied to the drawing of larger objects, such as fossil shells, serial sections of corals, brachiopods, etc. Here it is most suitable to use a camera with a lens, rather than a box, for convenience of focussing. A plate of glass is strapped to the back of the camera, and an accurate tracing may be easily made to any desired magnification. In the case of serial sections the use of Kodatrace has an added advantage, for several sketches may be superimposed, so that the change in structure stands out very clearly.

Naturally all the work has to be done in a dark room and the source of light must be shaded, so that the image on the Kodatrace is the only bright object. Under suitable conditions a surprisingly clear image is obtained permitting the sketching of minute detail.

21. A. THE AMMONITE GENERA *DISCOHOPLITES*, SPATH, AND *HYPHOPLITES*, SPATH, FROM THE UPPERMOST ALBIAN ROCKS OF DORSET.

Exhibited by C. W. WRIGHT and E. V. WRIGHT.

These two genera are the presumed descendants of the Gault genus *Euhoplites* and in common with that group have a well marked ventral sulcus. The exhibit consisted of specimens from the uppermost Albian (*dispar-perinflatum* subzone) of the Dorset coast. It included seven species of *Discohoplites*, one new, and four of *Hyphoplites*, one new. The latter genus is predominantly Cenomanian and a study of these Dorset Albian specimens, which include a number of passage forms, has shown in some detail the probable relationships and lines of descent of the group.

Thus it is probable that *Hyphoplites falcatus* (Mantell) is derived by way of *H. campichei* Spath from *Discohoplites subfalcatus* (Semenow), and a new Albian species of *Hyphoplites*, found also at Perte-du-Rhone, gives rise to *H. curvatus* (Mant.) and *H. crassofalcatus* (Semenow).

B. THE PERIGNATHIC GIRDLES OF CERTAIN CRETACEOUS ECHINOIDEA.

The perignathic apparatus of a number of regular echinoids from the Cretaceous has been successfully exposed. The exhibit included several species in which the girdle had not previously been described, and, with the aid of enlarged diagrams, showed clearly that the girdle differed, not only in different genera, but also in different species within the limits of the generic type. *Echinocyphus* and *Zeuglopleurus* were shown to have an insignificant girdle compared with *Tetragramma*, *Trochotiara* or *Phymosoma*. Of particular interest was a fragment of an echinoid from the Sponge Gravels of Faringdon showing, in its girdle, affinities with the anomalous genus *Allomma* (represented by *A. noumanniae* of the Cenomanian).

22. TERTIARY FOSSIL *TURRIDAE* [PLEUROTOMIDAE] TO DEMONSTRATE THEIR UTILITY AS HORIZON INDICATORS.

Exhibited by ARTHUR WRIGLEY.

MIDLAND GROUP.

FIELD MEETING REPORTS, 1944.

[*Received* 12*th December*, 1944.]

The Middle Bunter Deposits of the Barr Beacon District, Saturday, 24th June.

Director : Miss E. M. Hignett, B.Sc.

SIXTEEN members of the Group met at the Scott Arms Inn at 2.30 p.m., and walked to the Queslett Sand and Gravel Company's quarry in the basal conglomerate of the Bunter Pebble Beds. Here (by kind permission of the Manager) they were able to examine a fine exposure in 60 ft. of this conglomerate.

A short talk was given on the possible regions of origin of the pebbles, it being pointed out that arguments had been put forward in support of both northern and southern origins. It was suggested that members should look for unusual pebbles amongst the predominant quartzite, particularly fossiliferous pebbles, or fragments of granite or conglomerate which might be correlated with some known outcrop of older rock. Dr. Matley spoke in favour of a southern origin, basing his arguments on the occurrence, in the pebbles, of Devonian fossils which are not known to occur anywhere north of Birmingham, and of the large proportion of tourmaline in the igneous rocks, some of which seem to be similar in composition to the schorl rock of Cornwall. He suggested that a survey of Normandy and the Channel Islands, might reveal in situ rocks, which could be correlated with the fragments yielded by the Bunter Pebbles.

Mr. Edwards showed the position of a 155 ft. boring, in which water stands at 7 ft.—i.e., many feet above the bottom of the quarry, evidence of faulting, which is used as a settling tank for the washing water, but does not retain the water overnight. The boring is capable of giving 16,000 gallons an hour. Later Dr. Raw picked out in the quarry evidence of faulting, which may have been responsible for this phenomena.

A large proportion of the pebbles examined were of fine-grained quartzite. These varied considerably in colour, and some were schistose in character. They were of all sizes up to 15 inches in diameter. The igneous fragments included porphyritic rhyolite, tourmalinised rhyolite, and volcanic ash. Their distinctly acid character, though suggesting an origin in an area of predominantly acid igneous rock, may be accounted for by the greater resistance of the acid compared with the basic types. The amount of weathering, probably by percolating water, to which these beds have been subjected, was shown by the common occurrence of Carboniferous cherts containing fossils, whereas no limestone pebbles were found at all. In the Llandovery Sandstone pebbles too, the fossil evidence was chiefly in the form of casts, the calcium carbonate shells having been dissolved away.

Pebbles of well consolidated breccias, vein quartz, tourmaline, and black chert were also found. The general hardness of the pebbles renders them suitable for road metal, for which, and for concrete aggregate, they are quarried here, on a very large scale.

After leaving the quarry, the party climbed the dip slope, and skirted the crest of Beacon Hill, to the foot of the scarp face of the basal conglomerate of the Middle Bunter which caps the hill. In a quarry in this face similar pebbles to those seen at Queslett were examined, and some quartzite pebbles containing worm tracks were found. Numerous small pits, sometimes containing crystalline silica, were noted on the surfaces of many of the pebbles, and these were explained as pressure points where one pebble rested on another. There is very little sand in the conglomerate, which is quite uncemented, and the pitting is probably in part due to the stones grinding into each other during earth tremors, and partly due to direct static pressure, when the formation was deeply buried under newer strata, now eroded away.

At the north end of the quarry the Barr Beacon beds were examined. These lie directly beneath the Middle Bunter, and were seen to be composed of bands of quartzite breccia alternating with thicker sandstone bands of fine clean sand. The possibility was expressed of these being a piedmont deposit contemporaneous with the Lower Mottled Sandstone of the Bunter, which does not occur in this district. It was pointed out that the thinness of the deposit was compatible with its being accumulated at the edge of a basin of deposition in Lower Bunter times, the sand possibly being aeolian in nature, while the breccia was laid down by flood waters from the surrounding hills in periods of storm. The quartzite fragments of the breccia point to a local origin, from an area of Cambrian quartzite. Professor Wills pointed out that evidence of the exact age of these beds was missing, but reminded members of Professor Boulton's comparison of them with the quartzite breccias of the Nechells and other borings in East Birmingham.

Tea was taken near to Barr Beacon, and from this place there was a good view across the Coal Measures which underlie the Bunter and form the industrial basin of West Bromwich and Wednesbury, this region being backed by the Dudley-Rowley ridge of Silurian and igneous rocks. After tea the Chairman of the Group proposed a vote of thanks to the Director.

REFERENCE.

Shotton, F. W. The Lower Bunter Sandstones of North Worcestershire and East Shropshire. *Geol. Mag.*, Vol. lxxiv, Dec., 1937, pp. 550-552

THE LICKEY HILLS.

Saturday, 22nd July.

Director : Professor L. J. Wills, Sc.D., F.G.S.

THIRTY members of the Group met at Rubery tram terminus at 2.15 p.m., and leaving the main Bromsgrove Road, walked to the Holy Well.

Here a talk was given on the topography of the countryside and the line of a large fault bringing Permian breccia against Upper Coal Measure clays, was pointed out. The small stream which starts in the Holy Well and runs down to Chadwick Pools has a large valley, which has probably been eroded along the site of the fault.

In a nearby roadside exposure the Permian breccia was examined, and was found to consist of angular fragments of all sizes, and mostly of Uriconium igneous rocks in a heavy clay matrix. The Director spoke of the probable origin of these beds, as a piedmont deposit laid down by flood waters, during heavy rains in a predominantly desert climate during Permian times. He pointed out, however, that there were no large outcrops of Uriconium rocks known today in any area of the Midlands close enough to have allowed these fragments to have been deposited with practically no rounding. Buried sources must be postulated under the newer rocks to the south and west.

The party then continued towards Chadwick Manor, and in a roadside exposure examined part of the basal conglomerate of the Bunter Pebbles, which is here about 40 ft. thick and rests on the Permian breccia. The pebbles were seen to be very well rounded as compared with the angular fragments of the breccia, indicating a much greater distance of transport by water. In this area, on the average, about 65 per cent. of the pebbles were of hard resistant quartzite, and about 25 per cent. of vein quartz.

From this point could be seen several low hills, rising well above the general level of the valley. The Director pointed out that these were capped and preserved by " umbrellas " of resistant glacial gravels, which must have covered this area at a height of over 700 ft. above present sea-level, in glacial times. The amount of erosion which has taken place since that time, to give the present topography, indicates that a considerable length of time must have passed since early glacial times.

The party then walked through Chadwick Manor on to the main Bromsgrove road near Lydiate Ash. Here a section of the Middle Bunter was examined in an abandoned quarry. The southern face showed numerous small faults, mostly with slight upthrows to the west, though one example of a trough fault was noticed. The faulting was made evident by a single marl band near the top of the exposure ; elsewhere the faulting was scarcely traceable in the current-bedded and jointed sandstone.

The party then continued to the Marlbrook Gravel Company's quarry, where (by kind permission of the Company), they were able to examine a fine exposure of the basal conglomerate of the Middle Bunter, resting on the Permian breccia. Professor Wills spoke about the possible origin of the Bunter Pebbles. He said that about 65 per cent. of the pebbles had yielded three types of fossils, which might help to trace the origin of these fragments. These types were :—

(a) Devonian fossils, which are not known to occur anywhere north of Devonshire. Most of the species are unknown in this country, but are found in France and Germany.
(b) Ordovician fossils from two horizons known in Normandy, viz. the Gres Armoricaine, and the Gres de May.
(c) Llandovery Sandstone fossils, probably of fairly local origin.

The fossil evidence, therefore, points to a derivation from Ordovician and Devonian rocks of Southern facies, for some of the pebbles, a view strengthened by the presence of tourmaline-bearing rocks. It has been suggested that the quartzite might have been derived from an old ridge across the present site of the English Channel. The Director, however, pointed out that the distance of 200 miles would have been too great for the transport of some of the larger pebbles, and suggested a source now buried under the Mesozoic rocks of S.E. England.

The party was shown a large heap of pebbles, rejected by screening, all of which were over 7 inches in diameter, one particularly large one measuring 15″ x 13″ x 12″. The Director pointed out that such pebbles could not have travelled a great distance, and therefore their identification must reveal the nature of the rocks exposed in the Midlands in Triassic times. He had found here one large pebble with the Devonian *Spirifer verneuilli*, previously regarded as limited to much more southerly areas. Nevertheless, most of the quartzites appeared to be of the Lickey-Nuneaton type, i.e., fairly local. In this latter category, also, are the Llandovery fossiliferous sandstones and quartzites. Among these large pebbles, cherts with carboniferous fossils were found to be fairly common. These were probably derived, not from Derbyshire, but from outcrops now buried under newer rocks.

In the north east of the quarry, the junction of the Pebble Beds, with the underlying Permian breccia, was examined. The breccia was stained a deep purple colour, due to the deposition of iron and manganese on the surfaces of the fragments. The upper surface of the breccia, however, where water percolating through the very porous basal conglomerate of the Middle Bunter had been held up on the less pervious breccia, was bleached to a very pale greenish colour.

Leaving the quarry, the party continued to Lickey, where in the beech wood just west of Lickey Hill the Pebble Beds rest directly on the Keele Beds of the Upper Coal Measures, indicating the unconformable nature of the Middle Bunter upon the older rocks in this district.

Tea, with strawberries, was taken at "the Chalet," and afterwards the Chairman of the Group proposed a hearty vote of thanks to the Director, and also to Miss Bauer, who had made all the arrangements..

NOTES ON SOME GLACIAL FEATURES IN NORTH EAST DERBYSHIRE.

By A. C. DALTON.

[*Received* 14*th February*, 1944.]
[*Read in abstract*, 3*rd February*, 1945.]

THE area covered by this paper is S.E. of Buxton, on the eastern edge of the Carboniferous Limestone, and is situated in the triangular area bounded by the rivers Wye in the south, the Derwent in the east, and the Noe in the north (Fig. 1). The limestone is here deeply dissected by ravines, as in Stoney Middleton Dale and Coombes Dale, whilst the shales and grits which are superimposed, have been denuded into wide valleys and bold escarpments.

Prof. A. H. Green in the Survey memoir of 1887 [**1***] records many scattered exposures of Drift (at Bakewell and Haddon) in the Wye Valley. The patchy nature of the Drift in this area was thought to support the submergence theory. Messrs. Gibson and Wedd, however, in the 1913 memoir [**2**] advance evidence of land ice, the latter referring to the Derwent being blocked by ice at Darley Dale. In 1929 Messrs. Jowett and Charlesworth [**3**] gave the results of their research into the " Glaciation of the Derbyshire Dome," which though concerned chiefly with the western side of the Pennines, discussed in considerable detail the influence of the " Dove Hole Gap " (1,100 ft.) on the glaciation of the Limestone Dome. Like previous workers they found the greater evidence of glaciation east of the gap from Buxton down the Dove and the Wye Valley to its confluence with the Derwent, in scattered patches of clays and erratics, an area just south of that described in the present paper (see Fig. 1). They commented on the absence of striae on the limestone and suggested it was partly due to its " solubility," but chiefly to its situation outside the area of the newer Drift " (p. 308). They, however, examined the valley of the Noe from Edale-Castleton, north of the area of this research, and concluded that " there is no glacial evidence either there, nor indeed at any locality in this area " (p. 315), but were puzzled as to why this is so, if as they believe the " N.W. ice passed the Dove Hole Gap which formed a diminutive Stainmore Pass, where the ice from the west overflowed the main watershed of the Pennines and proceeded in a general south-easterly direction down the valleys of the Wye, and the Derwent, and the Dove " (pp. 314-5).

During 1942 the author had the opportunity of watching the construction of part of a cross-country trench between Calver Sough and Wardlow Mires (6in. Map Derbyshire XVI). Although only about two feet deep, this trench revealed information of very considerable importance. In so far as the solid rocks are concerned it passed from the Edale Shales to the Carboniferous Limestone, the ground level rising from about 450 ft. O.D., at the former passing 1,000 ft. O.D. towards the latter. At about the same time a few erratics had been disclosed in the overburden of the works of the Cupola Quarries Ltd., in Stoney Middleton Dale. The evidence there was insufficient to prove the existence of a real glacial deposit, but the combined evidence of the quarries and the trench leads to a definite conclusion.

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* For List of References see p. 31.

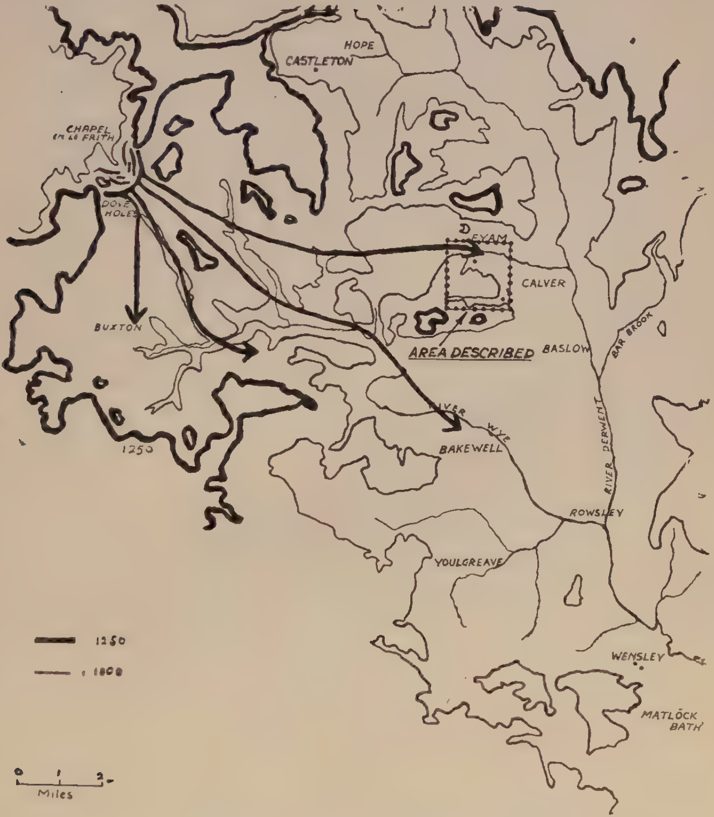

Fig. 1.—Map of District showing suggested direction of Ice through the Dove Hole Gap.

In the following description of the materials found in the trench the numbers refer to corresponding sections marked on map (Fig. 2). No. 1, is in Calver Sough, near the entrance to Coombes Dale.

No.	O.D.	Observation.
1.	460–500 ft.	Alluvial soil, but as 500 ft. was reached a bed of limestone-gravels was noticed, as if from some local drainage.
2.	500–600 ft.	Edale Shales becoming broken and passing into clay.
3.	600–700 ft.	Stiff yellow clay with erratics, biotite granite, porphyritic plagioclase granite, micro granite, basalts, limestones, cherts, sandstones and grits.

No.	O.D.	Observation.
4.	700–775 ft.	Passing into rubbly clayey soil with limestone increasing at 775,1, erratic limestone stained red. Black limestone below the covering of soil (See arrow.)
5.	775–800 ft.	Thin soil, white limestone replaces black. (See arrow.)
6	800–900 ft.	Yellow clay. Three grooves (with water-worn sides) in limestone cross the trench.
7.	900–1,000 ft.	Heavy yellow clay with cherts and water-worn limestone
8.		Black peaty soil } On loam.
9.		Brown soil
10.	1,000–1,070 ft.	Stiff yellow clay with fine rubble limestone and chert similar to silica replacement beds at Bradwell.

The most interesting point in the trench occurred just below 700 ft. O.D., where the first (micro granite) erratic was found in the yellow clay, a discovery soon followed by that of the other travelled rocks. The local concentration of the erratics was pronounced, but there is no corresponding topographical feature that could today account for it. Some erratics have been found previously in the neighbourhood (chiefly near the vicarage), but most of them were doleritic and their resemblance to local rock-types masked their significance. In association with the new discoveries they afford additional evidence of considerable glacial action in an area where drift had not previously been reported. Yellow clay, like that with the erratics at 700 ft. O.D., appears again at 800 ft. O.D. and 1,000 ft. O.D., but at their higher exposures only limestones and cherts were found in it and the fragments showed signs of considerable erosion. In the section at 1,000 ft. O.D. (Farnley Lane) the chert resembled the silica replacement material that occurs a few miles away to the North-West, at Bradwell. I have ventured to consider this yellow clay as a true "Boulder Clay," thin and impersistent though it may be, and I have marked it as "Till" on the map. Besides the larger erratics it yields a high proportion of silica-sand on elutriation.

Drift occurs in many hollows on the limestone uplands, and on the north side of Coombes Dale the cliff above the 600 ft. contour is covered by it, and pebbles and small boulders of sandstone and grit occur in considerable abundance. In a boggy patch near the 700 ft. contour, where the presence of bog-plants bespoke a clay subsoil, a block of sandstone was found (with rounded edges) measuring 6in. x 3in. x 2in. (see arrow on map).

In Stoney Middleton Dale, at the Cupola Works, there is a glacial deposit of considerable interest. A bed of dirty brown clay occurs in a hollow in the limestone at about 800 ft. O.D., in association with gravel, which contains numerous limestone erratics (up to a ton in weight), many of which are polished and striated. There are not many far-travelled erratics, but among them are garnetiferous ashes (presumably from the Lake District), basalt, quartzite and various grits. There is a particularly concentrated

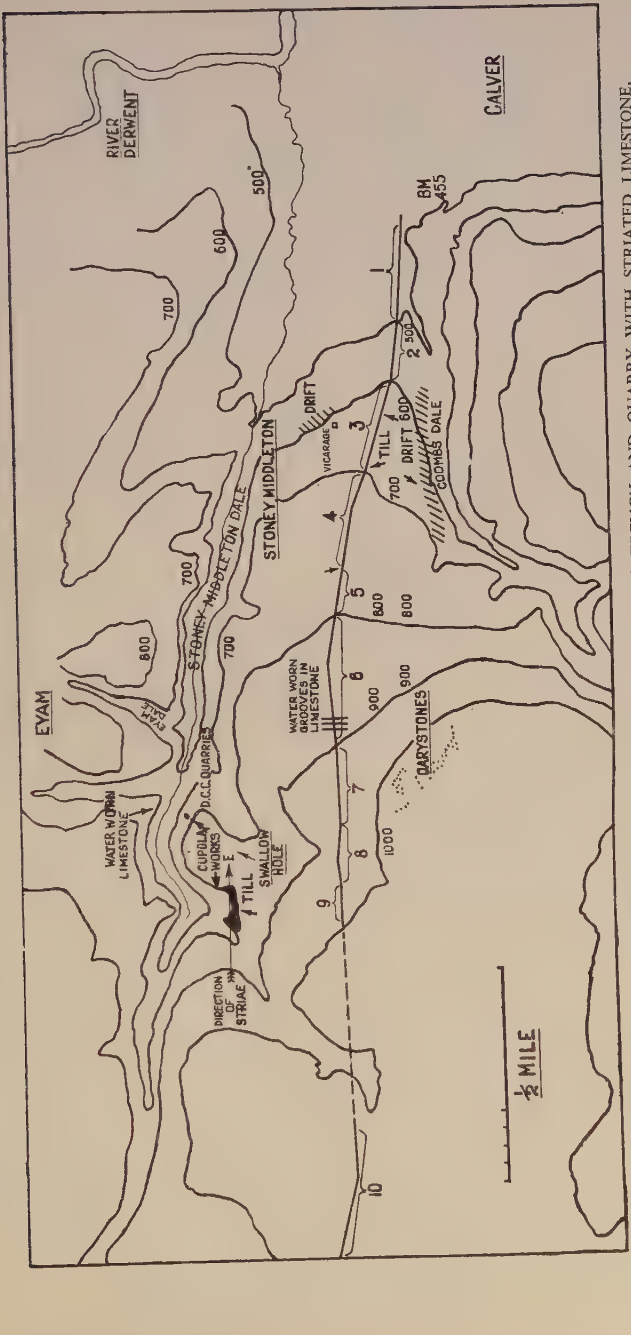

Fig. 2.—Map of Stoney Middleton, showing position of trench and quarry with striated limestone.

accumulation of limestone boulders at the western corner of the pit ; here also is exposed a water-worn surface of the bed-rock strongly suggesting grikes. A natural exposure of a similarly channelled surface (locally known as oarystones) can be seen about half a mile south-east of the quarry. As the removal of this overburden proceeded, the newly-bared surface of the limestone was found to be rounded, polished and striated in a typically glaciated fashion. The direction of the striae was approximately from west to east.

The striation of the limestone at a height between 700 and 800 ft. O.D. is in itself an important fact in the glaciation of Derbyshire, but its association with the occurrence of the erratics above enumerated reopens the question of the extention of the Western Ice-sheet into the district. It is usually agreed that the Dove-Hole Col (Fig. 1) marks the path of its penetration, although Prof. Kendall thought that this col might mark the place of overflow of water from a lake at Chapel-en-le-Frith Miss E. Dale in 1900 [**4**] and Messrs. Jowett and Charlesworth in 1929 suggest that land ice itself crossed this gap, which now seems more in accord with the present facts.

About 400 yards east of the Cupola quarry is the County Council's road-metal quarry, in which the remains of a swallow hole can be seen at about 750 ft. O.D. The solution effects of this swallet extend down fissures in the limestone to a considerable depth. The cavity of the main hole, like that of the connected fissures, is filled with a brownish yellow clay containing many rock-fragments, mostly of local origin. This clay is very similar to the yellow clay of the trench at about 1,000 ft. O.D. (No. 10, on map). On elutriation both clays yield the same coarse residue of silica sand, chert, limestone, barytes and fluorspar.

If the two yellow clays (one at 1,000 ft. O.D., and the other in a swallet hole whose top is at 750 ft. O.D.) are really identical they would provide interesting evidence as to the incidence of glacial waters flowing at higher levels than the ice-tongue that filled the valleys. Mr. Wedd describes a dry valley at Wensley Dale [**2**] as an overflow channel caused by the blocking action of ice in the Derwent Valley standing up to the 700 ft. contour.

In a former paper I have pointed out the importance and effects of the phase of stagnation in the course of the decay of an ice-sheet [**5**]. May not the phenomena now described as occurring between 750 ft. and 1,000 ft. O.D. in Derbyshire bear a similar explanation ?

I am indebted to Prof. W. G. Fearnsides, F.R.S., for making a special journey to confirm the polishing and striation of the limestone in situ at the Cupola quarry, and to the Geological Survey for kindly identifying the erratics recorded in this paper. My thanks to W. Robinson, Esq., of the Cupola Quarry are also due for allowing me full opportunities in his quarries.

REFERENCES.

1. 1887. " Geology of North Derbyshire," *Mem Geol. Survey*, 2nd Ed.
2. 1913. " Geology of Northern Part of Derbyshire Coal Field," *Mem. Geol. Surv.*,
3. Jewett, A., and Prof. J. K. Charlesworth. " The Glacial Geology of the Derbyshire Dome," *Quart. Journ. Geol. Soc.*, lxxxv, No. 339.
4. Dale, E. 1900. " Scenery and Geology of the Peak of Derbyshire," p. 125.
5. Dalton, A. C. 1941. " Lake Humber as Interpreted by the Glaciation of England and Wales." *North Western Naturalist*, vol. xvi, No. 4.

THE ANNUAL REPORT OF THE COUNCIL OF THE GEOLOGISTS' ASSOCIATION FOR THE YEAR 1944.

[Adopted at the Annual General Meeting on 3rd March, 1945.]

THE numerical strength of the Association on December 31st, 1944, was as follows :—

Honorary Members	18
Ordinary Members :—	
Life Members (compounded)	116
Annual Subscribers ...	1079
	1213

During the year 91 new members (a record number) were elected, and the Association lost 22 members through death, resignation and other causes. Despite the war conditions the membership continues to rise, and shows an increase of 69 over that of the previous year.

The list of deceased members is as follows :—H. J. T. Beadnell (obituary notice in Vol. LIV, p. 38), A. W. Clayden, G. W. Colenutt, F. Davies, E. H. Davison, K. W. Earle, A. Farrar, W. J. Gibson, E. J. Marsh, A. W. Oke, Miss A. P. Pearse, J. J. Powell, G. H. Richards, H. Tryon and Sir A. Smith Woodward.

Obituary notices will be published in the "Proceedings."

FINANCE

At the meeting on January 6th, 1945, Mr. C. T. A. Gaster and Mr. G. A. Kellaway were elected Auditors of the accounts for the year 1944. The audit was arranged to take place on January 27th, but unfortunately Mr. Kellaway was prevented by illness from being present. It was found impracticable to make other arrangements and the accounts for 1944 have therefore been audited by Mr. Gaster alone.

The financial position is very satisfactory. No special significance attaches to the fact that the General Purposes Account shows an excess of expenditure over income of £33 12s. 10d. ; all that this means is that part of the expenditure for the year has been met from the accumulated funds instead of by a transfer from one of the Special Funds. The income from admission fees and annual subscriptions, at £506 10s., shows an increase of £25 10s. over the amount received in 1943, and is back practically to the pre-war level. The income from sales is a nett amount, after deducting the sums spent on the purchase of back numbers of *Proceedings* in an endeavour to replace those lost by enemy action.

Compounding Fund

£100 of the balance in this fund was invested during the year in 3% savings bonds, 1965-75, and £60 was transferred to the General Purposes Account, leaving a balance in hand in the fund at the close of the year of £76 12s. 4d.

Bequest Funds

In the last annual report a bequest of £300 from the late Mr. H. H. Fawcett was announced. The estate proved insufficient to pay the bequest in full, and the amount actually received, after payment of legacy duty, was £216 14s. 11d. £200 of this, received earlier in the year, has been invested in 3% defence bonds ; the balance, received just before the end of the year, has not yet been invested.

The New Zealand 4½% stock, 1944, of the Bequest Funds, was converted during the year to a 3½% stock, 1960-70.

G. W. Young Geological Investigation Fund

No grants were made during the year, and the balance in the fund now amounts to £80, of which £20 is ear-marked in respect of a grant made to Mr. R. Casey in 1940.

Foulerton Award Fund

One award of £10 was made during the year, the balance remaining in the fund at the end of the year being £14 16s. 8d.

ACCOUNTS FOR THE YEAR ENDING DECEMBER 31ST, 1944.

GENERAL PURPOSES ACCOUNT.

INCOME.

	£	s.	d.	£	s.	d.
To Admission Fees—						
Received for 1944 Elections	41	0	0			
Received for Arrears	3	0	0			
	44	0	0			
Less Arrears at December 31st, 1943, £5, estimated to realise	2	0	0			
	42	0	0			
Add Arrears at December 31st, 1944, £4, estimated to realise	2	0	0	44	0	0
To Annual Subscriptions :—						
(1) Received in 1939 and 1942 for 1944 ...	2	0	0			
(2) Received in 1943 for 1944	52	0	0			
(3) Received in 1944 for 1944	365	10	0			
(4) Received in 1944 for arrears	43	0	0			
	462	10	0			
Less Arrears at December 31st, 1943, £296 10s., estimated to realise	40	0	0			
	422	10	0			
Add Arrears at December 31st, 1944, £359, estimated to realise	40	0	0	462	10	0
,, Sale of Publications				6	1	8
,, Transfer from other Accounts						
From Illustrations Fund Account (for Illustrations)	60	0	0			
,, Compounding Fund	60	0	0	120	0	0
,, Excess of Expenditure over Income				33	12	10
				£666	4	6

EXPENDITURE.

	£	s.	d.	£	s.	d.
By "Proceedings" of the Associations (Vol. LIV, Part 4, and Vol. LV, Parts 1-3)						
(1) Printing	353	19	9			
(2) Illustrations (a) Blocks and Plates ...	46	11	0			
(b) Printing	17	6	0			
(3) Author's separate copies	14	3	0	431	19	9
,, Printing Monthly Circulars				35	5	0
,, Stationery				20	15	0
,, Expenses at Meetings				27	17	6
,, Expenses at Field Meetings				1	15	4
,, Addressing and Stock-keeping				45	5	0
,, Postages				67	8	2
,, Insurance					12	3
,, Incidental Expenses				5	6	6
,, Yearly transfer to Reserve Fund for Index and List of Members				30	0	0
				£666	4	6

BALANCE SHEET, DECEMBER 31st, 1944.

LIABILITIES.

	£	s.	d.	£	s.	d.
To Annual Subscriptions received in advance :—						
In 1943 for 1945	1	10	0			
In 1944 for 1945	50	0	0			
In 1943 for 1946	1	10	0			
In 1944 for 1946	2	0	0			
In 1943 for 1947		10	0			
In 1944 for 1947	1	0	0			
In 1944 for 1948-51	2	0	0	58	10	0
,, Sundry Creditors						
Messrs. Benham & Co. Ltd.				2	17	6
,, Special Funds :—						
Illustrations Fund	7	16	9			
Illustrations Fund (Capital)	20	0	0			
Reserve Fund for Index and List of Members	48	0	0			
Compounding Fund	1,681	19	11			
Bequest Funds	782	17	2	2,540	13	10
				2,602	1	4
Accumulated Funds at January 1st, 1944	170	4	11			
Deduct Excess of Expenditure over Income for the year	33	12	10	136	12	1
				£2,738	13	5

ASSETS.

	£	s.	d.	£	s.	d.
By Investments (Special Funds) at cost or value when acquired :—						
Bequest Funds—						
£143 8 9 3½% War Stock, at value when acquired	141	14	0			
£150 New Zealand 3½% Stock 1960/64, at value when acquired	122	5	0			
£285 3% Defence Bonds, at cost	285	0	0			
£100 3% Savings Bonds, 1960/70, at cost	100	0	0	648	19	0
Compounding Fund—						
£1,217 2 6 Nottingham Corporation 3% Irredeemable Stock, at cost	1,152	13	2			
£200 3% Savings Bonds, 1955/65, at cost	200	0	0			
£170 3½% War Stock, at cost	152	14	5			
£100 3% Savings Bonds, 1965/75, at cost	100	0	0	1,605	7	7
Illustrations Fund (Capital)—						
£21 0 10 Metropolitan Water Board 3% B Stock, at cost				20	0	0
,, Annual Subscriptions in Arrears, £359, estimated to realise				40	0	0
,, Admission Fees in Arrears, £4, estimated to realise				2	0	0
,, Cash at Bankers and in hand :						
At Bankers	113	19	1			
In Office	42	0	6	155	19	7
,, Special Funds :						
Illustrations Fund at Bankers	7	16	9			
Compounding Fund at Bankers	76	12	4			
Reserve Fund for Index and List of Members at Bankers	48	0	0			
Bequest Fund at Bankers	133	18	2	266	7	3
				£2,738	13	5

SPECIAL ACCOUNTS.

ILLUSTRATIONS FUND.

	£	s.	d.		£	s.	d.
To Balance in hand on January 1st, 1944	26	6	9	By Transfer to General Purposes Account for Illustrations	60	0	0
„ Donations and Subscriptions	40	17	6	„ Balance December 31st, 1944, at Bankers	7	16	9
„ Transfer from Illustrations Fund (Capital)		12	6				
	£67	16	9		£67	16	9

ILLUSTRATIONS FUND (CAPITAL).

	£	s.	d.		£	s.	d.
To Balance in hand on January 1st, 1944	0	0	0	By Transfer to Illustrations Fund		12	6
„ Dividends as received :—				„ Balance December 31st, 1944	0	0	0
£21 0 10 Metropolitan Water Board 3% B Stock		12	6				
	£0	12	6		£0	12	6

COMPOUNDING FUND.

		£	s.	d.		£	s.	d.
To Balance in hand on January 1st, 1944		97	13	2	By Purchase of £100 3% Savings Bonds, 1965/75	100	0	0
„ Composition Fees received during the year		90	10	0	„ Transfer to General Purposes Account	60	0	0
„ Dividends as received :—					„ Balance December 31st, 1944, at Bankers	76	12	4
£1,217 2 6 Nottingham Corporation 3% Stock	36 10 2							
£170 0 0 3½% War Stock	5 19 0							
£200 0 0 3% Savings Bonds...	6 0 0							
		48	9	2				
		£236	12	4		£236	12	4

RESERVE FUND FOR INDEX AND LIST OF MEMBERS.

	£	s.	d.		£	s.	d.
To Balance in hand on January 1st, 1944	18	0	0	By Balance December 31st, 1944, at Bankers	48	0	0
„ Yearly Reservation for 1944	30	0	0				
	£48	0	0		£48	0	0

SPECIAL ACCOUNTS (*continued*).

BEQUEST FUNDS.

		£ s. d.		£ s. d.
To Balance in hand on January 1st, 1944 … … … …		100 11 9	By Purchase of £200 3% Defence Bonds (Fawcett Bequest) … …	200 0 0
,, Legacy from H. H. Fawcett … … … … …		216 14 11	,, Balance December 31st, 1944, at Bankers … … …	133 18 2
,, Dividends as received :—				
£143 8 9 3½% War Stock … … …	£5 0 6			
£150 0 0 New Zealand 3½% Stock… …	6 0 0			
£85 0 0 3% Defence Bonds … …	2 11 0			
£100 0 0 3% Savings Bonds 1960/70 …	3 0 0			
		16 11 6		
		£333 18 2		£333 18 2

"TRUST" FUNDS.

FOULERTON AWARD FUND.

	£ s. d.		£ s. d.
To Balance in hand on January 1st, 1944 … … … …	12 1 8	By Award to H. A. Hayward, M.B.E., F.G.S. … … …	10 0 0
,, Dividends as received—		,, Balance 31st December, 1944, at Bankers … … …	14 16 8
£255 0 0 Southern Railway 5% Guaranteed Preference Stock … … … … … … …	6 7 6		
,, Income Tax repayment for 1943-1944 … … … …	6 7 6		
	£24 16 8		£24 16 8

G. W. YOUNG GEOLOGICAL INVESTIGATION FUND.

	£ s. d.		£ s. d.
To Balance in hand on January 1st, 1944 … … … …	71 0 0	By Income Tax recovered for 1943, repaid to Public Trustee …	10 0 0
,, Income for 1944 received from the Public Trustee … …	9 0 0	,, Balance 31st December, 1944, at Bankers … … …	80 0 0
,, Income Tax repayment for 1943 … … … … …	10 0 0		
	£90 0 0		£90 0 0

I have compared these statements with the books and accounts presented to me and find them to agree.

I have also verified the investments of £1,217 2 6 Nottingham Corporation Stock, £200 3% Savings Bonds, 1955/65 £100 3% Savings Bonds, 1965/75, and £170 3½% War Stock of the Compounding Fund, £255 Southern Railway 5% Guaranteed Preference Stock of the Foulerton Award Fund, £143 8 9 3½% War Stock, £150 New Zealand 3½% Stock 1960/64, £285 3% Defence Bonds and £100 3% Savings Bonds 1960/70 of the Bequest Funds, and £21 0 10 Metropolitan Water Board 3% B Stock of the Illustrations Fund (Capital).

CHRISTOPHER T. A. GASTER, *Auditor*.

E. C. MARTIN, *Treasurer*.

27th January, 1945.

PUBLICATIONS

Publications Committee.—The Committee consisted of the officers (7), together with Mr. T. Eastwood, Dr. A. F. Hallimond, Dr. R. O. Jones, Dr. K. P. Oakley, Dr. R. W. Pocock, Prof. H. H. Read, Dr. Alan Wood and Mr. A. Wrigley. The Committee met on four occasions and considered twenty-one original papers, five Field Meeting reports, and the report of the Reunion in June. Recommendations were made to the Council on these contributions offered to the Association.

The Proceedings.—The moderate amount of paper allowed for the *Proceedings* has permitted the Association to publish the greater part of the original work which has been submitted, several papers have, however, been left over for 1945.

Volume LV for 1944 consists of 229 pages, and was issued in the usual four parts. This volume contains a Presidential Address, twelve original papers, six reports of Field Meetings, a record of twenty-one years' work of the N.E. Lancashire Group, and the Annual Report of the Council. The illustrations comprises eleven plates and twenty-six text figures.

Members will be pleased to learn that Council has agreed revert to the normal type for the *Proceedings*.

MEETINGS

Eleven meetings were held, at which four papers were read, seven papers were read in abstract, and six lectures and one demonstration were given. Particulars of these will be furnished later in the Session Report.

The thanks of the Association are due to the Authors and Lecturers. The attendance at meetings was well maintained, averaging 62.

The Ordinary and Annual General Meetings were held at the apartments of the Geological Society of London and the Committee meetings at the Imperial College of Science and Technology (Royal School of Mines).

Tea was provided either before or after the Ordinary Meetings.

The Association's thanks are due to the respective authorities for the generous facilities afforded.

REUNION.

The Annual Reunion was held at King's College on Saturday, 3rd June. A number of interesting exhibits were shown and several short demonstrations were given by members. Thanks are due to the authorities, the organisers and the members concerned.

A full account of this meeting will be given in the *Proceedings*.

FIELD MEETINGS

The appointment (by Council) of Dr. G. W. Himus to succeed Miss E. White was confirmed at the Annual General Meeting. The Committee consisted of the Officers and Miss Dix, Messrs. E. P. Bottley, T. Eastwood, W. F. Fleet, K. P. Oakley, A. Templeman and A. Wrigley.

Six half-day meetings and one long Field Meeting were held, of which reports have been, or will be, published in the *Proceedings*.

The best thanks of the Association are due to the Directors for organising and conducting the meetings in difficult circumstances.

THE LIBRARY

During the year the Library has remained evacuated with that of University College, but arrangements have now been made by which members may borrow volumes of certain periodicals (listed in the December circular) by post. The thanks of the Association are due to the donors of several books, pamphlets and maps, a list of which will be given in the *Proceedings*.

NORTH-EAST LANCASHIRE GROUP

Chairman : J. Ranson, A.M.I.M.E., F.G.S.

Joint Secretaries : A. Bray, M.Sc., A.Inst.M.M. (for correspondence) and Mrs. E. J. Harrop, B.A., B.Sc.

During the year six lectures were delivered and three Field Meetings were held.

At the Annual General Meeting the Chairman and Secretaries were re-elected with a new Committee. The thanks of the Group to the Education Committee and the College authorities for the use of rooms in the Blackburn Technical College was proposed and carried.

MIDLAND GROUP

Chairman : Dr. F. Raw, D.Sc., F.G.S.

Secretary : Miss Grace M. Bauer.

Committee : Professor L. J. Wills, Miss E. M. Hignett, A. E. Lyon, Dr. C. E. Marshall, Dr. D. Parkinson and Miss M. E. Tomlinson.

During the year, five Lecture Meetings were held at the Geological Department, the University, Birmingham, and there were Field Meetings. Particulars will be published in the *Proceedings*. The attendance was well maintained.

Thanks are due to Professor Wills for the use of the Geology Department at the University, Birmingham.

WEALD RESEARCH COMMITTEE

Some systematic work has been re-started on a small scale, although little is possible under war conditions. The paper by Mr. G. S. Sweeting entitled " Wealden Iron Ore and the History of its Industry " was published in the *Proceedings*. It was the thirty-second communication by the Committee.

TRUSTEES

The Trustees of the Association are :—

Managing : Mr. F. N. Ashcroft, M.A., F.G.S., F.C.S., F.R.G.S., and Mr. S. Hazzeldine Warren, F.G.S.

Custodian : The Royal Bank of Scotland, Western Branch.

FOULERTON AWARD

The Foulerton Award for the year was given to Mr. H. A. Hayward, M.B.E., F.G.S., for services to geology.

HOUSE LIST

Mr. W. P. D. Stebbing retires as a Senior Vice-President. Miss H. M. Muir-Wood, Messrs. T. Eastwood, R. O. Jones and H. E. Taylor retire as Ordinary Members of Council. Thanks are due to these members for services rendered to the Association.

Owing to enemy action in November our General Secretary (Mr. A. G. Bell) was compelled, with regret, to relinquish his post, at least for a time. Temporary arrangements were made, and it is hoped that inconvenience to members was avoided.

REPORT OF THE SESSION, 1944.

ORDINARY MEETING, *January 8th*, 1944.—Professor H. H. Read, D.Sc., A.R.C.S., F.R.S., F.G.S., President, in the chair.

Desmond Lloyd Edwards, Gwilym Owen Evans, Gilbert Wilson Green, Cyril William Hart-Jones, B.Sc., Ph.D., Mrs. Hilda Himus, Nathaniel James Llewellyn, and Thomas Roy Maylor Wakeling were elected Members of the Association.

Messrs. A. D. Stubbs and C. T. A. Gaster were elected to audit the accounts for 1943.

The following lecture was delivered :—" Geology and Health," by C. E. N. Bromehead, B.A., F.G.S.

ORDINARY MEETING, *February 5th*, 1944.—Mr. C. E. N. Bromehead, B.A., F.G.S., Vice-President, in the chair.

Anthony William Allen, Philip Cambridge, Robert Swinfen Gale, Rudolph Glossop, Ronald Frank Goossens, Cecil O. Harvey, B.Sc., A.R.C.S., A.I.C., Capt. Frank Lofts, Matthew Gavin Mason and Frederick Henry Stewart, B.Sc., Ph.D. were elected Members of the Association.

The following lecture was delivered :—“ The Geology and Scenery of Tanganyika Territory, East Africa,” by Sir Edmund O. Teale, D.Sc., F.G.S.

ANNUAL GENERAL MEETING, *March 4th*, 1944.—Professor H. H. Read, D.Sc., A.R.C.S., F.R.S., F.G.S., President, in the chair.

The Annual Report of the Council (already circulated) was taken as read. It was moved by Dr. L. J. Spencer, and seconded by Miss Yeates, “ that the Report of the Council, including the Statement of Accounts, be adopted as the Annual Report of the Association for 1944.” The resolution was carried *nem. con.*

The President declared the following members duly elected as Officers and Members of the Council in accordance with Rule XIII :—President : A. S. Kennard, A.L.S., F.G.S. Vice-Presidents : Miss Emily Dix, D.Sc., F.G.S. ; W. P. D. Stebbing, F.S.A., F.G.S., L.R.I.B.A. ; C. E. N. Bromehead, B.A., F.G.S. ; Professor H. H. Read, D.Sc., A.R.C.S., F.R.S., F.G.S. ; R. W. Pocock, D.Sc., F.G.S. Treasurer : E. C. Martin, B.Sc., A.I.C., F.G.S. Secretaries : General, A. G. Bell, I.S.O., B.Sc., F.G.S. ; Field Meetings, G. W. Himus, Ph.D., M.I.Chem.E., F.G.S. ; Publications Committee, A. J. Bull, Ph.D., M.Sc., F.G.S. Editor : G. S. Sweeting, D.I.C., F.G.S. Librarian : L. R. Cox, M.A., Sc.D., F.G.S. Twelve other Members of the Council : E. P. Bottley, F.G.S. ; T. Eastwood, A.R.C.S., F.G.S. ; A. F. Hallimond, M.A., Sc.D., F.G.S. ; Capt. F. Jones, T.D., Ph.D., M.Sc., F.G.S. ; R. O. Jones, Ph.D., M.Sc., F.G.S. ; A. T. Marston, L.D.S., F.G.S. ; Miss H. M. Muir-Wood, D.Sc., F.G.S. ; M. A. Ockenden, F.G.S., M.I.Mech.E. ; H. E. Taylor, F.G.S. ; Miss E. White, B.Sc., F.R.G.S., F.G.S., Alan Wood, B.Sc., Ph.D., F.G.S. ; A. Wrigley.

It was moved by Prof. R. C. Gale, seconded by A. M. Withers, and duly carried, “ that the best thanks of the Association be given to the retiring President, the Officers, the retiring members of Council, and the Auditors.”

The Foulerton Award was presented to Mr. H. A. Hayward, M.B.E., F.G.S., in recognition of services rendered to geology.

The President said :—

> Mr. Hayward, for a score of years you have been active in the affairs of this Association. On the administrative side you have served on the Council and have been Secretary to the Publications Committee for 1932 to 1940. You have conducted Field Meetings in the Weald and you carried out with great efficiency the onerous duties of Excursion Secretary for the Field Meeting in the Swiss Alps in 1926. You have contributed to our *Proceedings* an account of your researches into the geology and physiography of the Dorking and Leith Hill districts. On these three counts, and on others of a more personal nature, you have deserved well of the Geologists' Association and it is with great pleasure and our best wishes that I present to you the Foulerton Award.

C. W. Hobley, C.M.G., A.M.Inst.C.E., F.G.S., L. Richardson, F.R.S.E., F.G.S. and R. L. Sherlock, D.Sc., F.G.S. were elected Honorary Members of the Association.

The President then delivered his address, entitled “ Meditations on Granite ; Part Two.”

On the motion of Dr. Sherlock, seconded by Mr. Busbridge, it was resolved "That the President's Address be printed and circulated among the members."

ORDINARY MEETING, *March 4th*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Alexander Murray Cockburn, B.Sc., Ph.D., F.R.S.E., Thomas Russell MacLaren Lawrie, B.Sc., F.G.S., Henry Basil Maber, Frederick Jacques Nelki, M.D., Alexander Curt Niven, William Markland Ogden, B.Sc., A.M.Inst.C.E., A.M.Inst.W.E., A.M.T.P.I., Alexander Sibbald, and William Edward Smith were elected Members of the Association.

ORDINARY MEETING, *March 31st*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Dr. A. Jefferson Bernhardt, D.P.H., L.R.C.P., Mrs. Winifred Alice Bottley, Miss Margaret Jean Buckerfield, B.A., Arthur Henry Dadd, Eric Herbert Hagon, Peter Mallinson, Kenneth Edmund Seal, Ivan Peter Simmons, Albert Ernest Henry Swaisland, and Miss Keren Bridget Tyrrell were elected Members of the Association.

The following paper was read :—" On the Origin of Folded Mountains (with special reference to the Western Alps) " by. A. J. Bull, Ph.D., F.G.S.

The following papers were read in abstract :—(1) " A Note on Tilted Folds and direction of Pitch," by J. Challinor, M.A., F.G.S. ; (2) " An Unusual Variety of Flint from Buckinghamshire," by K. P. Oakley, B.Sc., Ph.D., F.G.S.

ORDINARY MEETING, *May 5th*, 1944.—Mr. C. E. N. Bromehead, B.A., F.G.S., Vice-President, in the chair.

Alfred Edmund Allcock and William Chuter Young, A.M.Inst. C.E. were elected Members of the Association.

The following paper was read :—" The Crayford Brickearths," by A. S. Kennard, A.L.S., F.G.S.

ORDINARY MEETING, *June 2nd*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Major Herbert Douglas Anthony, M.A., B.Sc., Ph.D., Cyril Edward Charman, and Lt. Peter Harker were elected Members of the Association.

The following lecture was delivered :—" Strategic Minerals," by Prof. W. R. Jones, D.Sc., D.I.C., F.G.S.

ORDINARY MEETING, *July 7th*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Brian Alexander Bailey, Miss Joan Brotherton, Miss Eileen Clark, Kenneth Alan Joysey, Samuel Morton McConnell, Miss Joan Amy McDonald, Geoffrey Dennis Nicholls, Miss Althea Ruth Thomasine Prideaux, Richard Patrick Suggate, and James Wright, F.R.S.E., F.G.S. were elected Members of the Association.

The following lecture was delivered :—" Limestone Deposition in the Bahamas," by Maurice Black, M.A., F.G.S.

The following papers were read in abstract :—(1) " The Stratigraphy of the Chalk of Sussex, Part III., Western Area. Arun Gap to the Hampshire Boundary, with Zonal Map," by Christopher T. A. Gaster, F.G.S. (2) " The Carboniferous of the Swinden Anticline, Yorkshire," by R. G. S. Hudson, D.Sc., F.G.S., and H. V. Dunnington, B.Sc.

The attendance at this meeting was only seventeen (the lowest of the year) : due, doubtless, to the fact that the Circular was delayed, and was not received by most Members until after the meeting.

ORDINARY MEETING, *October 7th*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Reginald James Bell, Miss Monica Laura Florence Boyack, Stanley Coe, Peter G. Dyson, Gerd Manfred Friedmann, Gilbert Alec Garceau, Armand Donald Lacaille, F.S.A., Edward Proctor, Miss June Elizabeth Rapson, Michael Squire Ryan, Frederick Charles Scott, Charles Fallows Tozer, Rudolph Jean Francois Ubaghs, and Oliver Arthur Warner were elected Members of the Association.

The following lecture was delivered :—" Man's Northward Progress in Britain during the Ice Age," by A. D. Lacaille, F.S.A.

ORDINARY MEETING, *November 4th*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Kenneth R. Ashby, B.A., Cecil Robert Knight Blundell, George Arthur Bull, Frank Davis, Ian Elliott Higginbottam, T. Oakes Hirst, M.A., Ph.D., Allan Henry Hodgkins, George Mills, J.P., F.G.S., Brian Trevor Neil Newland, Filippo Luigi Ravelli, John Rookledge, Raymond Bromley Tabor, William Hallam Ward, Miss Josephine Monica Wignall, and Miss Dorothy Ethel Wisden were elected Members of the Association.

The following paper was read :—" On Jet Coal in the Chalk of Kent," by L. Hawkes, D.Sc., F.G.S.

Dr. E. Dix exhibited samples of Millerite (NiS) from a new locality in the Coal Measures of South Wales.

ORDINARY MEETING, *December 2nd*, 1944.—Mr. A. S. Kennard, A.L.S., F.G.S., President, in the chair.

Capt. Frederick William Allen, R.A., Miss Gwendoline Alice Creek, John Richard Harpum, Eugene Maynard Hughes, Albin Digby Hunt, Miss Rhona MacRae MacLennan, B.Sc., Ph.D., John Francis Osborne, Norman John Greville Pounds, Miss Joan Hunter Sanderson, B.Sc., Ronald Algernon George Savigear, Gilbert Wilson, and John Dugdale Holt Wiseman, M.A., Ph.D., F.G.S., were elected Members of the Association.

The following lecture was delivered :—" The Geology of the Oilfields of the Middle East," by G. M. Lees, M.C., D.F.C., Ph.D., F.G.S.

On a motion from the President, the Lecturer was invited to submit the substance of his discourse for publication in The *Proceedings*.

The following papers were read in abstract :—(1) " The Primary and Secondary Elements of a Fold," by John Challinor, M.A., F.G.S. (2) " The Application of Tilt to a Fold," by G. D. Hobson, Ph.D., D.I.C., F.G.S. (3) " Note on the Origin of Island Arcs," by A. J. Bull, M.Sc., Ph.D., F.G.S.

FIELD MEETINGS, 1944.

Field meetings were resumed in 1944, after a lapse of nearly four years, and a successful, though somewhat restricted programme was carried out.

It seems desirable at this place to give a brief summary of the events which led to the abandonment of field meetings in 1940 for otherwise, there will be an unexplained hiatus in the records, and, in course of time, the circumstances will be forgotten and an important part of the history of the Association will be irretrievably lost.

At the outbreak of war, in September, 1939, all meetings were deprecated by the Government in the belief that London would be subjected to immediate and heavy air raids. The remaining Field Meetings and the ordinary meetings were therefore cancelled. No raids having taken place, however, the activities of the Association were resumed and a programme of Field Meetings and visits was drawn up for 1940. Until, and including Whitsun, the programme was carried out without interruption, but meetings projected for August and later were cancelled, owing to the disastrous military situation which involved the complete occupation by Germany of the Channel ports in France and the Low Countries.

Heavy air raids began in August and continued until the middle of May, 1941 ; during this period there could be no incentive to the preparation of a programme of field meetings, and even after the final heavy raid on London, which took place on May 11th, there was nothing to indicate that the cessation of the attacks was more than a lull during which something worse was preparing.

No Field Meetings were held in 1942 or 1943, although during this period there was only sporadic enemy action over Great Britain, and that mainly confined to coastal areas. It would seem that the habit of holding Field Meetings having been broken, the abnormal conditions arising from the war were becoming accepted as normal, with the result that no steps were taken to resume one of the most important activities of the Association.

Towards the end of 1943, however, enquiries began to be received as to the possibility of arranging Field Meetings and the Committee was, therefore, reconstituted and instructed by Council to draw up a tentative programme. The Committee consisted of the following :—

G. W. Himus (Chairman and Secretary), the Officers of the Association, and Miss E. Dix, Messrs. E. P. Bottley, T. Eastwood, W. F. Fleet, K. P. Oakley, A. Templeman and A. Wrigley.

The following meetings were arranged :—

i. Sunday, 2nd April. A joint meeting with the Hertfordshire Natural History Society and Field Club at the Swallow Holes, Water End, North Mimms, under the direction of Mr. P. Evans. This was a half-day visit and was attended by nine Members of the Association.

ii. Saturday, 13th May. Dr. A. Wood led a party of between 35 and 40 Members and guests to a new section in the Lower London Tertiaries at West Wickham, Kent.

iii. Saturday, 20th May. Dr. A. J. Bull and Mr. F. Gossling took a party of 28 on a traverse over the Chalk and Tertiary beds in the neighbourhood of Croydon.

iv. Saturday, 27th May. Nearly 40 Members and visitors spent an enjoyable afternoon under the direction of Professor W. B. R. King in the large pit at Eastwood's Cement Works, Barrington, near Cambridge, where they studied a fine section of Gault, Cambridge Greensand, Chalk and Boulder Clay.

v. Saturday, 10th June. Mr. G. S. Sweeting had arranged to conduct a traverse through the Central Weald from Southborough, near Tunbridge Wells to Eridge, and all arrangements had been made. The news that, early on June 6th, British and American troops had landed in strength in Normandy was quickly followed by a number of cancellations from members who had intended to take part in the meeting and, all things considered, it was deemed advisable to defer the meeting till a more propitious date.

It was provisionally arranged to hold the deferred meeting on Saturday, 12th August, but on June 15th a heavy and sustained attack by flying bombs began on Southern England, more particularly the London area. As a consequence of this attack, which lasted till the end of August, a redistribution of the anti-aircraft defences took place which rendered the district to be visited decidedly unhealthy, so the meeting was again held over sine die.

vi. Wednesday, 19th July. A party was to have been led by Mr. C. E. N. Bromehead on a " Walk Round London," from the Embankment at Charing Cross to Kensington Gardens. The attack by flying bombs was now at its height and only five Members put in an appearance. After a short talk by the Director, the party dispersed.

vii. Saturday, 22nd July. Mr. A. Wrigley led a Field Meeting to the historic Rock Pit in Sundridge Park, Elmstead Wood, Kent. There was a certain amount of interference with the proceedings arising from air-raid alerts and the passage of flying bombs overhead, but 9 Members spent an enjoyable afternoon studying this classic section.

viii. 24th August to 2nd September. Professors A. H. Cox and H. P. Lewis directed a very enjoyable meeting at Dolgelly to study the Cambrian and Ordovician rocks of the district. Far from air-raid alerts and dangers of flying bombs, a party of 20 Members spent a strenuous eight days in the field, where, under expert guidance, they were initiated into the fascinations and complexities of the structure of this complicated region. Not the least welcome feature of the meeting, for those who came from the London district, was the possibility of sleeping soundly *upstairs*, in a real bed, confident that their rest would not be broken by untoward happenings (officially known as " incidents ") in the night.

The party was fortunate to have with them Professor A. A. Miller of the University of Reading and Dr. F. Raw of Birmingham University, both of whom shed light on a number of the problems raised by the Directors.

A number of other meetings had been mooted and preliminary enquiries and arrangements made, but had to be abandoned either owing to war-time restrictions or to the advent of the flying bombs. Taking all in all, however, the programme worked out as well (or perhaps better) than might have been expected, though less well than was hoped. The Association owes a deep debt of gratitude to the Directors for the time and labour they expended in preparing and conducting the Field Meetings. Thanks are also due in no less measure to those Directors whose meetings were cancelled owing to adverse circumstances.

NORTH-EAST LANCASHIRE GROUP.

The following Meetings and Field Meetings were held during 1944 :—

January 28th.—Lecture, " The Physical Features of a Limestone District," Mrs. E. J. Harrop, B.A., B.Sc.

February 18th.—Lecture, " Geology and Planning," E. Morton, M.Sc., P.A.I.W.E.

March 24th.—Chairman's Address, " The Geology of the Swiss Alps," J. Ranson, F.G.S., A.M.I.M.E.

April 29th.—Field Meeting : Visit to a Collection of Agates. Leader : W. Cocker, J.P.

June 24th.—Field Meeting : Revidge and Mellor. Leader : J. Ranson, F.G.S., A.M.I.M.E.

July 29th.—Field Meeting : The Permian Rocks of Parbold. Leader : A. Bray, M.Sc., A.Inst.M.M.

October 27th.—Lecture, "Technical Literature," A. Bray, M.Sc., A.Inst.M.M.

November 17th.—Lecture, "The Investigation of Fossil Plants," E. Lacy, B.Sc., F.L.S.

December 15th.—Lecture, "Genes, Embryos and Fossils," Miss E. Adcock, Ph.D.

MIDLAND GROUP.

The following Meetings and Field Meetings were held during 1944 :—

February.—Lecture, "The Post-Glacial Development of North-West Europe," Dr. Hans von Pichler.

March.—Lecture, "Open-Cast Coal Mining Using Modern Equipment," A. L. Lyon, B.Eng., A.M.Inst.C.E., F.R.S.A.

May.—Lecture, "Some Notes on the Water Supply of the Coventry District," J. D. Hughes.

June.—Field Meeting : Queslett and Barr Beacon. Director : Miss E. M. Hignett.

July.—Field meeting : Rubery and Lydiate Ash. Director : Professor L. J. Wills, M.A., Sc.D., F.G.S.

November.—Lecture, "The South Downs," A. J. Bull, Ph.D., F.G.S.

DONATIONS TO THE LIBRARY DURING THE YEAR 1944.

AMERICAN MUSEUM OF NATURAL HISTORY.—Bashford Dean Memorial Volume, Archaic Fishes (edit. E. W. Gudger). Articles 7, 8. 1940, 1942.

BIRMINGHAM UNIVERSITY (GEOLOGICAL DEPT.)

LAMONT, A. & R. H. S. ROBERTSON. The Raw Materials of Scotland, Alkali Felspar, etc. 1943.

MARSHALL, C. E. The Identification and Correlation of Coal Seams. 1944.

MARSHALL, C. E. The Constitution of Anthraxylon and its Relation to Type and Rank Variation in Coal Seams. 1943.

PARKINSON, D. The Origin and Structure of the Lower Viséan Reef-Knolls of the Clitheroe District. Lancashire. 1944.

BRAZIL (DEPARTAMENTO NACIONAL DA PRODUÇÃO MINERAL).—Boletin, Nos. 55-57. 1943. Avulso, Nos. 49-56. 1943.

CEYLON (DEPARTMENT OF MINERALOGY).—Professional Paper No. 1. 1943.

CHINA (NATIONAL GEOLOGICAL SURVEY).—Palaeontologia Sinica, N. Ser. D, No. 10. (F. Weidenreich. The Skull of *Sinanthropus pekinensis*.). 1943.

Davis, A. G. The Triumvirate : A Chapter in the Heroic Age of Geology. 1944.

Devonshire Association.—Rep. & Trans., vol. lxxv. 1943.

Green, J. F. N.—Ordnance Survey 6-inch sheets, Devonshire 72 S.W., 83 N.E. & S.E., 84 N.W. & S.W., 94 N.W., with the coastal platforms marked.

Odell, N. E.—The Petrography of the Franz Josef Fjord Region, North-East Greenland. 1944.

Porto (Muséo e Laboratório Mineraólgico e geológico).

Ribeiro, O. Novas observaçaoes geológicas e morfológicas nos arridores de Vila-Velha-de-Ródao. 1943.

Neiva, J. M. G. O dólmen da Fonte Coberta. 1943.

And 15 other pamphlets.

OBITUARY NOTICES, 1944.

George William Colenutt died suddenly on June 18th, 1944, at the age of 82. He is best known for his discovery in 1888 of vertebrate remains in the Osborne Beds between Ryde and King's Quay (*Geol. Mag.* 1888, p. 358). His discoveries were rewarded by valuable memoirs by H. Woodward on Fossil Prawns from the Osborne Beds (*Geol. Mag.* 1903, p. 97) and E. T. Newton on " The Remains of Amia," etc. (*Q.J.G.S.*, vol. lv., 1899). In these beds, Colenutt found a shoal of small fish, *Diplomystus* (*Clupea*) *vectensis* (Newton), specimens of which he neatly trimmed up from slabs of shale and distributed to continental museums and any student who came his way. He was always interested to find the famous insect bed in the Bembridge Marls and for years practised a routine of carrying away, in a wheelbarrow if necessary, small outcrops as they presented themselves from time to time at low tide and examined them at home. The writer well remembers the outbuildings and stables where these and kindred operations were performed. It was not until 1929 that his labours were rewarded in finding a rich exposure at Gurnard Point quite near to the original site discovered by E. J. A'Court Smith seventy years previously. Thus Colenutt was able to present choice material to the Hope Museum, Oxford, an undescribed aquatic Potamogeton to the British Museum (Nat. Hist.) and a fine representative collection of insect remains to the Museum of Isle of Wight Geology. His last contribution to the Geology of the Osborne Beds appeared in *Geol. Mag.* 1903. He was very successful in his experiments and apparatus for extracting small fossils from Eocene and Oligocene Clays ; his last paper was on the subject and appeared in our *Proceedings* (1941, vol. lii).

The writer made his first acquaintance with the Oligocene of the Isle of Wight under the guidance of Colenutt. His powerful physique and commanding appearance impressed one immediately and within half an hour of his company one learned that he was an art connoisseur, critic and collector, an authority on Prehistory, and a good all-round archæologist and naturalist. His interests were wide, for in his correspondence with the writer such subjects as coast erosion, well borings, lignite mining and the manufacture of Vandyke brown from lignite are discussed.

Colenutt was a well-known solicitor and had practised at Ryde and Cowes since 1885. He took great interest in local societies and directed the excursions of the Hants Field Club to the Island on more than fifty occasions. He was a joint director on the occasions of the Association meetings of 1919 and 1931, was the first President of the Isle of Wight Natural History Society (1919) and a Vice-President until his death. His geological and archæological finds, for he only kept a small reference collection, were ever at the disposal of science and the student. Colenutt joined the Association in 1895 and in his passing it loses a veteran and a great amateur. [A.G.D.]

Arthur William Clayden, M.A., F.G.S., F.C.S., who joined the Association in 1899, and was a Life Member, was born in 1855 at Boston, Lincs. Educated at University College School and Christs' College, Cambridge, where he took the Natural Science Tripos in 1876, he was appointed Science Master at Bath College in 1878, University Extension Lecturer in 1887, and later Hon. Sec. of the British Association Committee on Meteorological Photography. In 1894 he became the first Principal of University College, Exeter, where he also occupied the chairs of Physics and Geology until 1922.

His publications included " Cloud Studies,"—a classic work carried by the R 34 on its journey across the Atlantic, " The History of Devonshire Scenery " and numerous papers on meteorology, photography, astronomy, physics and geology. In 1899 he constructed a working model of Ocean Currents (now in the University of Cambridge) which was used in an advisory capacity in the construction of the Panama Canal. In addition he did much work on Black Electric Sparks and a Beamless searchlight.

His hobbies were really side-lines of his academic work, e.g., cloud altitudes, but he was also a painter of no mean distinction and a gardener who combined science with artistic appreciation.

[H.D.]

Ewart Davies, Ph.D., B.Sc., died on 21st October, 1942, at the age of 38. He was educated at Tredegar County School and Cardiff University, studying under Prof. A. H. Cox, and graduating in 1929. Subsequently he entered Trinity College, Cambridge, where he worked under Dr. G. M. Elles, taking his Ph.D. in 1932. Later, he was appointed Science Master at Tredegar Secondary School. While conducting a school party, working on a farm, he contracted typhoid fever, which proved fatal.

[J.M.D.]

Ernest Henry Davison, B.Sc., F.G.S., M.I.Q., died at Derby on 9th August, 1944, as the result of an accident. He was educated at Cheltenham Grammar School and graduated at London University in 1902 with Honours in Geology.

He was sometime Science Master at Sandbach Grammar School, Chester, and was appointed to the Staff of Camborne School of Mines in 1909, where he was Head of the Geology Dept. until his retirement in 1940. He was an enthusiastic teacher and developed the geology and mineralogy courses to a high standard. He instituted a holiday course in Economic and Field Geology, attended by many students and teachers from all parts of Britain. He also lectured at several English universities, and before the British Association ; his W.E.A. and popular lectures brought the interest of his subject before the public.

For over 20 years, Mr. Davison was most actively associated with the Royal Geological Society of Cornwall. He received the Bolitho Gold Medal in 1920 : was its President in 1933-4 and for many years Curator and Hon. Sec. He published many papers on Cornish Geology as a result of intensive research especially on veinstones. In 1930 the Society published his well-known "Handbook of Cornish Geology" (2 edns.). Other publications include "Field Tests for Minerals," "Field Determination of Rocks," "Geological Notes," and innumerable papers for mining and geological periodicals.

In the field, he organised period excursions for the British Association, Mineralogical Society and Geologists' Association; members will recall the enjoyable meeting in Cornwall at Easter, 1938. With characteristic energy, he devoted himself to the economic applications of his subject. Consulting work on mines, quarries, water supply, and china clay was frequently undertaken, and in most legal aspects of such work, favourable decisions were obtained.

Since his retirement from teaching, Mr. Davison was fully employed by the Ministry of Supply, chiefly on outcrop coal. At the time of his tragic death at 67, he was about to return to his home at Plymstock to report on quarries in the West of England.

[J.R.]

Old University College students will have learnt with deep regret of the death of KENNETH WILSON EARLE, D.Sc., F.G.S., at his home in Bournemouth, on March 21st, 1944. He had been a member of the Association since 1913. The son of Mr. Thomas Benjamin Earle, an architect and surveyor, and a member of an old Huguenot family, he was born in 1891, and was educated at Berkhamsted Grammar School and at University College, where he studied Geology under Professor E. J. Garwood. He was University Scholar in this subject in 1912, and graduated with honours in 1914. Poor health led to his rejection from military service, and he devoted three years to school-teaching, but in 1917 he was invited by Professor Garwood to return to his old college as Demonstrator and Museum Assistant. He began an investigation of the Lower Carboniferous rocks of West Cumberland, assisted by a research grant from the Royal Society. But he was that rare combination, a geologist who is also a mathematician, and the thesis for which he was, in 1918, awarded the M.Sc. degree, of London University was on the subject of "The Mathematical Consideration of some Stratigraphical Problems." Two years later he left his post to take up an appointment for three years as Government Geologist in the Windward and Leeward Islands of the British West Indies. In 1924 he returned to University College as Curator of the Johnston-Lavis Geophysical Collection; in the following year he became Assistant, and in 1927 Senior Assistant in the Geology Department, where he undertook the map-classes and museum-work, and in his later years lectured on Mineralogy and Economic Geology. But his health was always poor, and in 1933 he vacated his post, and retired to live with his parents at Berkhamsted, subsequently moving to Bournemouth.

83. He was a native of Launceston, Cornwall, trained for the medical profession at University College, London, and was awarded the degree of M.D. with a gold medal.

For over 50 years he was a well-known and well-beloved medical practitioner in Bristol. Many will remember him driving about the city with a ‘carriage and pair’ long after motor-cars were the order of the day.

In addition to his private practice he was interested in the Bristol Dispensary and his long connexion with the Methodists showed his desire to help people in their religious life as well as in their physical needs.

He was greatly interested in natural history and was a member of the Bristol Naturalists’ Society from 1925 until his death, being chiefly connected with the Geological Section. Although he at no time made a serious study of any branch of geology, he was intensely interested in all field activities and was always present at field meetings if his medical practice permitted. His collection of rocks and fossils reflect these interests in the field and form a resume of his activities in geology. He also found much pleasure in the study of ferns and mosses, although in this, as in other branches of natural history, he was essentially an out-of-doors naturalist. At all times he was a delightful companion in the field.

Dr. Powell leaves a widow, two sons and one daughter, two of whom are also in the medical profession.

The writer is indebted to his brother-in-law Professor Frank Robinson, late of Baptist College, Bristol, for some of the details incorporated into this note.

[F.S.W.]

George Henry Richards, who died on December 6th, 1944, at the age of 90, joined the Association in 1922. Born at Redruth, Cornwall, on April 18th, 1854, he was apprenticed to a local firm of booksellers in Stationer’s Hall, with whom he stayed until his retirement over 40 years later. As a young man he attended classes in chemistry, and at the age of 20 he passed a Government examination in this subject. Later, proceeding to London, he attended lectures by Prof. Tennant. During the years of his retirement he became interested in geology and devoted much time to collecting Cornish and other minerals, many of which he regularly exhibited at Conversazione meetings of the Association.

In 1936, after the death of his wife, he moved to Wales, but soon returned to the South of England, where at Hastings he gave some lectures on natural history.

[E.P.B.]

Henry Tryon, who joined the Association in 1877 and was a Life Member, was born at Buckfastleigh, South Devon, on 20th December, 1856, and died at Brisbane, Queensland, Australia, on 15th November, 1943. He was the son of Mr. H. C. Tryon, and after leaving school became a medical student at the London Hospital. He did not finish his course, however, but devoted himself to natural science. He was one of the older school of naturalists and though specialising in entomology had a good broad knowledge of geology and botany. He travelled extensively and one of his first natural history expeditions was to follow in the footsteps of Linnaeus, tramping alone all over Sweden in this connection. Later he journeyed to New Zealand where he managed a grazing property for his father for a short time. Here he devoted himself very assiduously to the natural history of the island and especially to the botany. Some years before his death he gave his complete collection of New Zealand plants to the State Herbarium at Brisbane.

Leaving New Zealand he came to Australia and obtained, in 1883, an appointment as Entomologist and Assistant at the Queensland Museum. In 1894 he was appointed Government Entomologist and in 1901 became also Vegetable Pathologist, holding the dual position in the Queensland Department of Agriculture and Stock until his retirement in 1921.

Apart from entomology and natural history, one of his most notable achievements was his introduction of the sugar cane Badila into Australia, after a visit to New Guinea for the express purpose of obtaining sugar cane varieties for introduction into Australia. In 1912 he was a member of a travelling commission appointed by the Queensland Government to tour the world for the purpose of finding insect and fungal pests of the prickly pear for introduction into Australia for the control of the prickly pear pest (*Opuntia inermis*). Among the insects introduced was *Cactoblastis cactorum* from the Argentine. Mr. Tryon actually brought some of the caterpillars alive to Brisbane, but failed to rear them through to the adult stage. They were later reintroduced and proved successful.

A complete list of his published works on economic entomology, etc., containing 136 titles, will be found in the Queensland Agricultural Journal for August, 1929. We are indebted for many of the particulars here given to an obituary notice in the same Journal for January, 1944.

[C.T.W.]

By the death on 2nd September, 1944, of SIR ARTHUR SMITH WOODWARD, LL.D., F.R.S., the Geologists' Association mourns the loss of a lifelong friend and helper. Full accounts of his life, his scientific work and his well-earned honours have been given in the *Times* of September 4th and *Nature*, whilst others will appear in the publications of the many Societies of which he was an honoured member or fellow, for he had a worldwide reputation. Here we are content to speak of his work for us. He joined the Association as a Life Member in 1883, was President 1904-1906, Vice-President 1903, 1906-1907, 1911-1914, 1920-1926, and served as an ordinary member of Council 1886-1889, 1892-1895, and 1901-1902. In 1925

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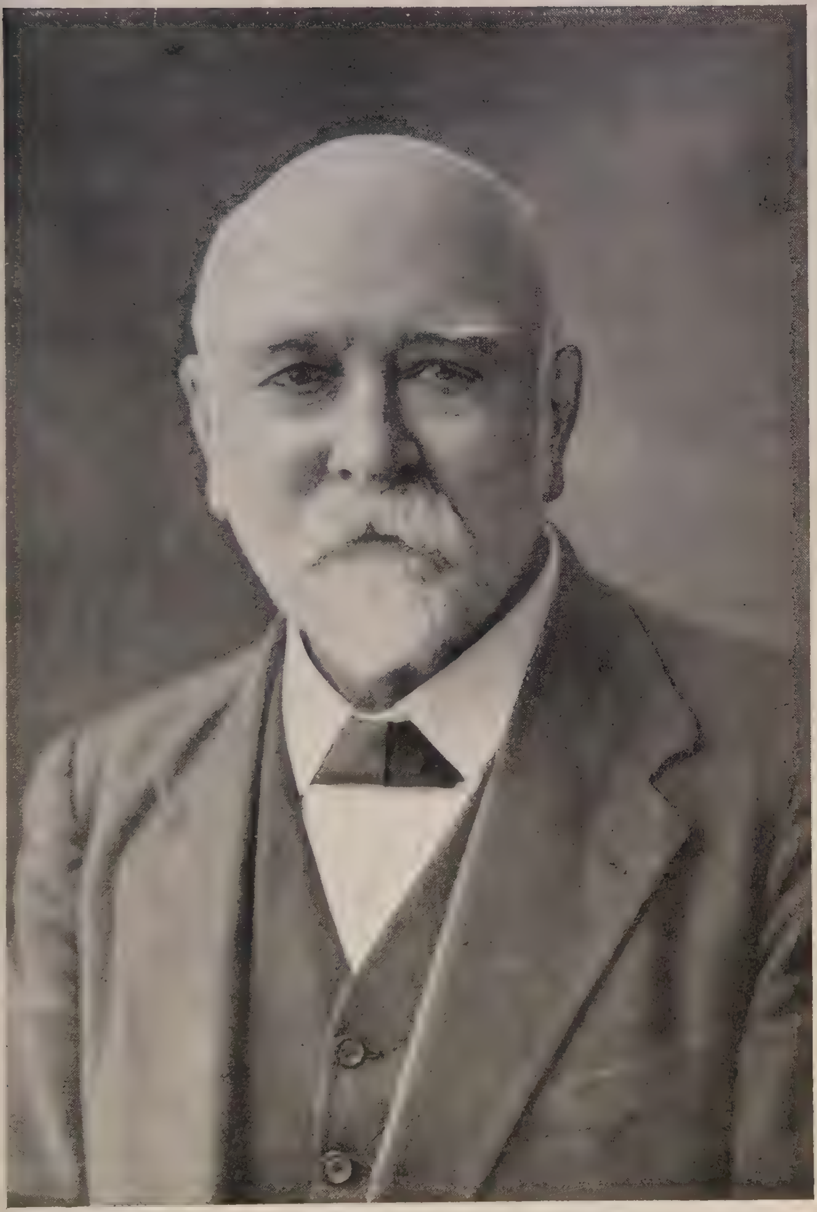
A constant attendant at meetings and excursions, he was also a frequent exhibitor of specimens of particular interest at the ordinary meetings and the annual soirees. All Palaeontologists are indebted to him, for he was secretary of the Palaeontographical Society from 1900 to 1934, a very difficult position, but he filled it admirably and the long series of monographs produced during that period is a worthy memorial to his fostering care.

He retained his enthusiasm for Geology right to the last and one can recall his presence at the Swanscombe Field Meeting in 1939, braving a bitter "Nor-Easter," having travelled from Haywards Heath and sadly hampered in his movements by the results of an accident. It is a relief to learn that he finished his book on the Piltdown skull before he crossed the bourne. We mourn the loss of a great scientific worker and a true friend. As a slight acknowledgment of his work for the Association and a tribute to his memory we have pleasure in presenting his photograph, for which we are indebted to Lady Smith Woodward.

BIBLIOGRAPHY OF PAPERS IN OUR *PROCEEDINGS*.

1886. The History of Fossil Crocodiles, vol. ix, pp. 288-344.
1887. On "Leathery Turtles," recent and fossil, and their occurrence in British Eocene deposits, vol. x, pp. 2-14.
1888. A Synopsis of the Vertebrate Fossils of the English Chalk, vol. x, pp. 273-338, one plate.
1889. On the Palaeontology of Sturgeons, vol. xi, pp. 24-44, one plate.
1890. On the fossil Fishes of the English Lower Oolites, vol. xi, pp. 285-306, one plate.
1892. Supplementary Observations on some Fossil Fishes of the English Lower Oolites, vol. xii, pp. 238-241, one plate.
1894. Notes on the Sharks' Teeth from British Cretaceous Formations, vol. xiii, pp. 190-200, 2 plates.
1895. Note on Megalosaurian Teeth discovered by Mr. J. Alstone in the Portlandian of Aylesbury, vol. xiv, pp. 31-2.
1899. Notes on the Teeth of Sharks and Skates from British Eocene Formations, vol. xvi, pp. 1-14, one plate.
1905. Modern Methods in the Study of Fossils, vol. xix, pp. 69-75. Presidential Address.
1905. Note on some Portions of Mososaurian Jaws obtained by Mr. G. E. Dibley, from the Middle Chalk of Cuxton, Kent, vol. xix, pp. 185-187.
1906. The Study of Fossil Fishes, vol. xix, pp. 266-282. Presidential address.
1910. Oh *Dipteronotus cyphus* Egerton, a ganoid Fish from the Lower Keuper of Bromsgrove, Worcestershire, vol. xxi, pp. 322-323.
1912. Note on a Maxilla of *Triconodon* from the Middle Purbeck Beds of Swanage, vol. xxiii, pp. 100-1.

In most cases the author provided the plates and illustrations. He set a very high standard, especially in his bibliographies in all his papers, and this was a great factor in raising the status of the Association to its present position.



SIR ARTHUR SMITH WOODWARD, LL.D., F.R.S.,
1864—1944
(President, Geologists' Association, 1904—06).

[*To face p.* 56.

MUSEUM DEMONSTRATIONS.

Either alone or with one of his colleagues he gave seven lectures on the contents of the galleries of the Fossil Vertebrata of the British Museum (Nat. Hist.).

March 19th, 1892 : Pleistocene Mammalia.

Sept. 11th, 1899 : Vertebrate Palaeontology. This was to a joint audience of the Association and the Société Belge de Géologie and Dr. Henry Woodward was the senior demonstrator.

March 15th, 1902 : Fossil Mammalia.

March 11th, 1905 : A joint demonstration by Dr. A. Smith Woodward and Dr. C. W. Andrews on Fossil Vertebrata.

March 10th, 1906 : Fossil Reptilia.

March 2nd, 1907 : Fossil Fishes.

February 25th, 1911 : Fossil Reptilia.

EXCURSIONS.

To Peterboro, July 10th, 1897. Directors, A. N. Leeds and Dr. A. Smith Woodward, vol. xv, pp. 188-193. Though a joint report it is easy to see who was the dominant partner. The bibliography is excellent.

To Swanage, May. 1910. Directors, F. Hovenden, H. W. Monckton, Dr. W. T. Ord and Dr. A. Smith Woodward. The last contributed part IV of the Report, vol. xxi, pp. 520-521.

LECTURES.

The Association is indebted to him for six lectures :

May 1st, 1891 : The Restoration of Extinct Animals.

March 14th, 1896 : Fossil Fishes.

March 6th, 1903 : On the Pliocene Bone bed of Concud, Teruel, Spain.

July 1st, 1904. The Geology and Fossils of the Ludlow District.

May 6th, 1910 : The History of the Study of Fossils.

December 1st, 1912 : Prehistoric paintings and drawings in the Caverns of Northern Spain.

Older members will recall these lectures with pleasure for the lucid manner in which he explained the various problems and for the excellent slides which he exhibited.

[A.S.K.]

SUMMER FIELD MEETING, 1944.

(August 24th—September 2nd.)

THE DOLGELLEY DISTRICT.

Report by the Directors,

Professor A. Hubert Cox, D.Sc., Ph.D., F.G.S., and Professor H. P. Lewis, M.A., Sc.D., F.G.S.

[*Received 5th February, 1945.*]

TWENTY-TWO members attended the Meeting, which was favoured with exceptionally fine weather over almost the whole period, only one day's programme suffering some curtailment.

Members assembled at the headquarters—the Royal Ship Hotel, Dolgelley—on August 24th. A small party who arrived on the afternoon train, took a short walk under the guidance of Professor Cox to the junction of the Ceunant and Aran streams, where the Ceunant Fault is exposed. Like the Bala Fault, of which it is an off-shoot, it behaves as a shatter-fault. Here Ffestiniog Beds are thrown against a dolerite intrusive into Arenig Grits, the *apparent* vertical displacement being estimated as nearly 3,000 feet ; the fault was seen to hade northwards towards the younger rock. The broad belt of highly brecciated and shattered rocks is well exposed in the steep bank of the Aran stream, the section being capped by a considerable thickness of boulder clay. Splendid examples of fault breccias are also exposed at intervals in the bed and south bank of the tributary Ceunant stream for some distance above its confluence with the Aran River.

On the return journey to the town the party stopped to examine a small but good exposure of the basal Arenig Flags, here considerably contact-altered by the adjacent dolerite, causing them to simulate Lingula Flags in appearance, so that their true nature was, for a long time, not realised.

Friday, August 25th, 1944.

Directors : Professor A. H. Cox and Professor H. P. Lewis.

BARMOUTH.

The party left Dolgelley at 9.40 a.m. by train to Barmouth, and assembled on the promenade to view the various members of the Harlech Grit succession exposed on the hillside above the town. Professor Cox outlined the succession and the distinctive physical features of the various groups into which Lapworth had subdivided the Harlech Series, and gave a brief account of Lapworth's researches in the area. The Director expressed his regret that Dr. Matley, who had been so closely associated with Lapworth, had, at the last moment, been prevented by illness from joining the party.

Members then walked to St. John's Church, where the lower part of the Manganese Shale group is well exposed, and Professor Lewis called attention to the short trial level which had been driven into the rock face in an attempt to exploit the manganese ore. He pointed out that, although some early surveyors had mapped the ore as lodes, or impregnations of softer strata by manganese oxides along the strike, later workers, particularly Lapworth and his associates, had recognised the truly bedded nature of the deposit and had used it as a datum plane in working out the structure and sequence of rocks within the dome. He added that within recent years Dr. Woodland[1] had mapped the one-foot band of ore and had shown that the beds immediately above and below it retain a remarkably uniform character over the whole area. Near the Church, the junction of the Manganese Shale with the Rhinog Grit, 30 feet below the ore, was not seen, but members were able to examine the upper part of the blue-grey mudstones, which lie below the ore, and the thin layer of deep green mudstone, crowded with cubes of pyrite and microscopic octahedra of magnetite, immediately underlying the ore-band. Above the ore, the laminated blue-grey " Bluestone " mudstones, about 6 feet thick, with a thin rippled layer of sphaerodialogite near the top, followed by the " Bluestone Grit," containing bands and lenticles of mudstone, in places showing black manganese weathering, were well displayed. Minor folding of the beds added to the interest of this section.

On ascending to a road which contours the hill immediately above the church, an old exploratory level, driven along a vertical quartz vein, was seen. The Director explained that mapping proved the vein to follow a steeply dipping fault running north-north-east. As is usually the case with north-south veins in this district, this particular vein is barren as regards any payable mineralisation.

A few yards west of this point openings on the manganese ore-bed showed the strata affected by the same folds as those already seen by the church immediately below.

Professor Lewis drew attention to the blocky weathering of the " Bluestone " above the ore, and the massive character of the succeeding " Bluestone Grit." He also gave a brief description of the ore and of its origin based on the work carried out by Dr. Woodland under his direction. Members collected specimens from the spoil heaps. The normal ore was seen to be a tough, compact, banded, jaspery or cherty rock breaking with subconchoidal or uneven fracture, the banding being due to alternating layers of chocolate-red and yellow colour, varied by an occasional bluish-black band containing a small amount of pyrolusite. In the typical ore the red material was observed to predominate and the yellow material to take the form of lenticles of varying thickness and lateral persistence. The Director stated that the ore had been found to consist essentially of manganese garnet (spessartite) and manganese carbonate (dialogite *or* rhodochrosite) in roughly equal proportions, with occasional free quartz and a very little manganese silicate (rhodonite). The red layers owe their colour and laminated appearance in thin section to the small amount of finely divided hematite which occurred as inclusions in the minute spessartites, these inclusions being very rare in the spessartites of the yellow portions of the ore. For several reasons, such as the laminated character of the red material, the patchy occurrence of the yellow material and the presence of numerous minute contraction cracks, especially in the yellow ore, the conclusion had been reached by Dr. Woodland that the rock was originally deposited by precipitation of manganese carbonate in colloidal form from solution and accompanying the flocculation of clayey and siliceous gel materials, while normal detrital sedimentation was absent. It was further pointed out that spessartite and rhodochrosite occur in varying amounts in the associated grits and mudstones, and that this presence of spessartite, both in the ore and, with abundant associated chlorite, in the other sediments, indicates that the rocks as a whole have been subjected to considerable regional metamorphism.

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[1] Woodland, A. W. " Petrological Studies in the Harlech Grit," *Geol. Mag.* (1938), pp. 366, 440, 529. " Lower Cambrian Manganese Ore of West Merionethshire, *Quart. Journ. Geol. Soc.* (1939), 95, pp. 1-35.

Moving still a few yards farther west the topmost beds of the Rhinog Grits were seen dipping under the Manganese Shale Group and forming a steep escarpment dropping down to the alluvial flats below. Some of the exposed grit surfaces are well glaciated, and in one place a scarp face is undercut and grooved in such manner as to prove that the ice movement was not downwards from the mountains above, but was along the face of the seaward-facing scarps. The ice was, therefore, not local ice, but Irish Sea ice jammed against the steep scarp and moving in a direction parallel to the present coast-line. Members were greatly impressed by the clearness of the exposures.

Immediately above this point the lowest beds of the Manganese Shale group succeed the Rhinog Grits quite abruptly, and a few feet above comes the manganese ore band. The outcrop of this band could be followed northwards for a mile or more along the hillside marked by the workings of the old Hafotty Mines. Some of the nearer workings were examined. The main ore bed was seen to be only about 1 foot thick with dips varying from 20° to 80°. Leaving the manganese mines members turned southwards on a slanting course uphill, then followed a path which contoured the hill above the town, and in so doing traversed the whole outcrop of the thick Manganese Shale Group with the strata almost continuously exposed. The route affords extensive views of Cardigan Bay and the hills of the Lleyn Peninsula with Bardsey Island in the distance. Professor Lewis drew attention to some of the nearer coastal features and to the long recurved spit extending northwards from the opposite shore of the Mawddach Estuary and reaching across nearly to Barmouth, thereby almost blocking the mouth of the estuary.

Professor Cox then pointed out the narrowness of the space available for building the older part of the town between the steep hill sides and the shore. He also indicated an area at the north end of the promenade where localised marine erosion caused great trouble for a number of years, to such an extent as to create an ultimate threat to a considerable part of the town. The first defence works seemed to have little effect, but later measures have, so far, proved effective. He mentioned other examples of quite recent changes along the neighbouring coast.

Resuming the traverse, a vertical dolerite dyke was seen cutting cleanly across the steeply inclined Manganese Shale and striking north-east. Quarrying had completely removed parts of the dyke, leaving a deep trench with vertical walls of country rock. Professor Cox gave the reasons for regarding the intrusion as probably belonging to the Tertiary suite, comparable with occurrences farther north in Carnarvonshire and Anglesey. Its mode of occurrence is quite different from that of all the other intrusions of the Barmouth-Dolgelley area. Members examined the contact effects on the sedimentary rocks and the chilling of the dyke margins.

A short distance beyond this intrusion the junction of the Manganese Shale Group with the overlying Barmouth Grits was reached. The junction is quite sharp, fine-grained shales being followed abruptly by pebbly quartzitic grits. At one place the outcrop of the junction bed was seen to be repeated by a small fault throwing a few feet only ; the structure was fully exposed in plan. The Barmouth Grits were seen to produce a very rough and craggy outcrop. Lunch was taken on the hill-side at this point with views of the nearby coast under brilliant sunshine.

The party then made a short and rather steep descent, following the edge of the great quarry in Barmouth Grits, ultimately descending by flights of steep steps to the main road. The massive and steeply dipping grit beds with clear cut bedding planes descending some 300 feet at an angle of about 65°, made an impressive picture.

After a short halt members reassembled in the quarry and examined the variable lithology of the conglomeratic grits. Most of the town buildings and walls were built of stone from this quarry. The floor of the quarry shows a quartz vein accompanying a thrust plane which appears nearly horizontal in the west wall of the quarry, but bends up sharply towards the east and behaves as a thrust from the west-north-west. This thrust is evidently responsible for the strike-hollow which the party had used to descend from the hills.

Rock-cuttings in the main road just beyond the quarry show the junction of the Barmouth Grits with the overlying Gamlan Beds, both groups dipping at about 65°. The Gamlan Beds here are shales closely resembling the Manganese Shales in most aspects of their lithology and presenting much the same type of regional low-grade metamorphism.

Dr. F. Raw drew members' attention to the "worm" borings characteristic of the Gamlan Beds and appearing immediately in the lowest beds of the group as exposed in this section, and he gave a brief account of his petrological studies on these rocks.

Continuing along the main road (here known as Porkington Terrace) past the entrance to Barmouth Bridge porphyrite sills are crossed. These sills follow approximately the top beds of the Gamlan Group. They make a strong feature which forces the road into a series of sharp bends through rock-cuttings very awkward for traffic. Immediately beyond the intrusions the dark shales of the Clogau Beds appear, the lowest members contact-altered by the sills beneath. The road runs slightly oblique to the strike and affords a continuous section of these beds down to the estuary shore at Aberamffra Harbour. At localities farther up the Mawddach Valley the Clogau Shales have yielded the oldest identifiable fossils (*Paradoxides hicksii* zone of the Middle Cambrian) so far recorded in the Dolgelley district, but fossils do not as yet appear to have been recorded from the Barmouth area.

At Aberamffra the black Clogau Shales are seen to be followed quite sharply by the lowest beds of the Lingula Flags—the Vigra Flags or lower division of the Maentwrog Beds according to Lapworth's grouping.

These beds with their abundant "ringers," i.e., pale quartzitic grit bands, are well displayed in the road-cuttings and cliff sections and offer a marked contrast to the evenly bedded black shales below. The junction here may be faulted, as there is no sign of certain transitional beds which are visible only a short distance away on the route to the Panorama Walk.

The party now retraced their steps to Porkington Terrace and then followed the ordinary route to the Panorama Walk. The way leads once more over the porphyrite sills here showing lit-par-lit junctions with the neighbouring shales. Then the road follows a strike hollow and dry valley along the outcrop of the Clogau Shales. Professor Miller considered that this valley marked the site of a lateral overflow channel. The path to Panorama Walk eventually leaves this valley at a road junction. Near this point there seem to be beds transitional between the dark Clogau Shales below and the typical Vigra Flags with prominent "ringer" bands above. These transitional beds are striped sandy shales which form a small scarp. The Vigra Flags, with several small sills, are well exposed all along the Panorama Walk and just below the summit there are one or two rather barren quartz veins, the Panorama Lodes, with some prospect trials. Professor Cox explained the salient features of the view with special reference to the foothills of the Cader Idris Range which were to be the venue of the morrow's excursion.

Members then returned to Barmouth, obtaining tea at cafes en route, reassembling for the 6 p.m. train to Dolgelley.

Saturday, August 26th.

Director : Professor A. H. Cox.

GWYNANT VALLEY AND ARTHOG.

The Foothills of the Cader Idris Range.

The route followed was as described in the report of an earlier Field Meeting.[1] The party travelled by train to Penmaenpool. At the station Professor Cox drew attention to the mountains of the Harlech Dome across the estuary and to the hills at Barmouth, and he indicated the geological relations of that area to the area now to be examined. Members then walked one mile along the main road west to Abergwynant.

From Penmaenpool the road led over a low col and then along a lateral valley running slightly oblique to the strike. Professor Miller, in a later talk, ascribed this valley and col to a marginal overflow channel incised in a relic of a 200-feet platform. At Pont Abergwynant a road-cutting by the bridge showed some of the topmost beds of the Ffestiniog division of the Lingula Flags, and the characteristic *Lingulella davisi* was obtained with some difficulty. Some amusement was caused when a party of 5 and 6 year old evacuees from the neighbouring Pont Kings Hostel, who were greatly intrigued by the members' energetic " chopping," produced much the best fossiliferous slab yet found at this locality. Professor Lewis then guided members up the Gwynant stream to a fossiliferous locality which he had discovered in the overlying Dolgelley Beds, where *Parabolina spinulosa* was collected. The party then crossed the steam and climbed the steep eastern bank to the road above. From a view-point near the school, Professor Cox indicated the principal geological features ; the strike of the topmost Ffestiniog Beds, the drift-filled hollow covering the Dolgelley Beds with exposures in the ravine just visited, also the position of the nearby intrusive masses of Craig-y-Castell lying in line with the hollow made by the Dolgelley Beds. The view northward was dominated by the striking scarps of the Niobe Beds of the Tremadoc Group, cut through by the Gwynant Valley. Members then continued by road past the school to a road junction which happens to mark the outcrop of the Lower Dictyonema Band which immediately overlies the Niobe Beds. Fossils were soon obtained from loose material on the wooded slopes. Continuing by the lower road a dolerite sill was crossed and its metamorphic effects on the Tremadoc Slates were well displayed by Pont Ty-gwyn, where the road crosses the Gwynant. Shortly beyond the bridge the position of a second and higher Dictyonema Band was indicated in the bank above the road and fossils were obtained. The road continues past a large sill of markedly ophitic dolerite with well-marked contact effects on the underlying Tremadoc Slates.

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[1] Cox, A. H. and Wells, A. K. *Proc. Geol. Assoc.*, vol. xxxviii, 1927, p. 319.

The Director explained that there appeared to be a strike fault just beyond this point, bringing Arenig shales and ashes against the Tremadoc Slates, since the basal Arenig quartzites and flags are not present in the Gwynant Valley section, though they are well developed along the strike a little farther west, as would be seen later in the day. Members examined a cliff of steeply dipping and well-bedded ashes of splintery china-stone ash type. The Director explained that these rocks occur near the top of the Arenig Series and that the immediately underlying shales on the opposite river bank yield extensiform graptolites. Beyond the ashes the road crosses the outcrop of the thick granophyre mass of the Crogenen intrusion. The basic marginal rocks are not seen in situ on the west side of the stream, but the debris forming the steep banks near the entrance to the house, ' King's,' consists mainly of the dark marginal rocks. Farther up the road there is a small cutting through normal granophyre in which the columnar structure is so regular as often to deceive the unwary into assuming that the rock is a bedded sedimentary rock. From this point it could be seen that the granophyre outcrop tends to form a hollow by contrast to the rocks on either side, and therefore behaves in marked contrast to the great granophyre of Cader Idris, which was visible in the distance forming the cliffs of the Foxes Path and Cyfrwy.

From this point the party turned southwards following the line of the gently sloping shelf above the ravine of the Gwynant Valley. It was clear that the gorge represented a rejuvenated tract incised in an originally matured valley floor. At the point where the party stood the change of slope was sharply defined and coincided almost exactly with the 400-feet contour. Lunch was taken on the hillside overlooking the gorge.

Turning westwards along the strike the party ascended a long slope of Tremadoc Beds lying between the two dolerites crossed earlier in the valley below. From this slope a view was obtained of the series of features across the Gwynant Valley.[1] Higher up, the slate outcrop narrows in wedge-shaped fashion owing to transgression by the northern dolerite and the transgressive sill forms a rock barrier damming Llyn Wylfa ; the barrier rocks are strongly glaciated.

Near this place the Arenig grits and flags (Basement Group), missing in the Gwynant Valley, appear from beneath the Pont Kings dolerite sill and make a small scarp which increases in magnitude along the south shore of Llyn Wylfa. Members followed this lake margin and crossed a peaty flat at the west end of the lake to examine the fossiliferous beds of the Asaphellus Flag division of the Tremadoc Series, here revealed by small trial holes. A good suite of fossils were soon obtained, including *Asaphellus homphrayi*, small *Lingulae*, *Conularia*, etc. Dr. Raw also found a perfectly formed six-lobed impression of a jelly-fish 2 or 3 inches across. This was a new discovery for the area and possibly a form new to science.

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[1] See illustration, Cox, A. H. and Wells, A. K., *Quart, Journ. Geol. Soc.*, vol. lxxvi, 1920, Pl. xvi, p. 322.

From Llyn Wylfa members climbed the scarp made by the Arenig Basement Beds seeing, at the top, good exposures of steeply dipping Extensus Flags ; then after negotiating an awkward mountain wall, found themselves faced with another scarp showing a complicated succession of rhyolitic ashes and agglomerates interbanded with slates and with small dolerite sills. The various rocks were briefly examined ; the slates have yielded extensiform graptolites, but on this occasion time did not permit extensive search.

Crossing a large dolerite sill the party arrived at the little upland tarn of Llyn Pen Moelyn, in view of a series of clearly displayed strike features due to ashy grits interbedded with the Llanvirnian Shales (Bifidus Beds). Crossing these outcrops, at which *Didymograptus bifidus* and *Orthoceras* sp. were collected, a short but steep scramble up the scarp of Pared y Cefn Hir enabled members to examine fine exposures of very coarse andesitic agglomerates interbedded with fine-grained felspathic ashes. The party then walked quickly along the long ridge with good views of the great wall of Tyrau Mawr (part of the Cader Idris Range) to the south, and of the Barmouth area to the north. Eventually the Cefn Hir ridge drops steeply to the Arthog or Crogenen Lakes. Professor Cox pointed out that there is no corresponding strike feature on the opposite side of the lakes, and he explained the reason as due to the westward transgression of the Crogenen granophyre into higher beds ; accordingly the Cefn Hir Ashes are not contact-altered on the far side of the lake and therefore make no large feature, though their presence is proved by mapping. The Cefn Hir ridge therefore owes its existence to the ashes being contact-altered where in contact with the granophyre. An interesting effect follows, in that the Cefn Hir ridge has to some extent protected the neighbouring Bifidus Beds from denudation with the result that the ashy grits (Bryn Brith Beds) in the Bifidus Series in their turn are enabled to make an unusually high and sharp feature, Bryn Brith, 1,256 feet. This in its turn has protected the underlying Arenig rocks, so that the Arenig rhyolitic rocks also make an unusually strong feature. The final result is the clearest and most completely exposed section of the strata from the base of the Arenig to the top of the Llanvirn that exists anywhere in the Dolgelley district.

The party made a rapid descent to Crogenen Lake, a few members making a small deviation among the crags of the steep dip slope of Cefn Hir, in order to see the intrusion-breccia where the acid granophyre has invaded and brecciated its own basic margin.

A short distance along the track round the lake a small quarry in the Bifidus Shales yielded numerous small tuning-fork graptolites, *Didymograptus stabilis*, *D. artus* and *D. bifidus*. Professor Miller also discovered a large and well-preserved specimen of *Ogygia buchi*, this being apparently the first record of a trilobite from this locality. This was the second important fossil discovery on this day's meeting, the other being the jellyfish from the Tremadoc Beds at Llyn Wylfa.

A quick descent was then made to Arthog to catch the 6 p.m. train to Dolgelley.

Sunday, August 27th.

Directors: Professor A. H. Cox and Professor H. P. Lewis.

CADER IDRIS.

The day opened with every prospect of perfect weather, but signs of change soon appeared and the start was made under dull and threatening skies. Proceeding on foot up the Cader Idris Road, the first stop was made a few hundred yards up the hill, where there is a narrow outcrop of Arenig Flags resting on an outlier of Rhobell Fawr rocks to the north and followed on the south by intrusive dolerite. The beds are contact-altered and are similar to and lie on the strike of the Arenig Flags seen in the Aran Valley just above Dolgelley. The Director explained that the position of the Arenig base in the Dolgelley area remained unknown for many years, and it was not until the Arthog area had been mapped that the true position of these beds was recognised. Shortly afterwards Dr. A. K. Wells found the important fossil *Bolopora undosa* at this locality. Professor Lewis then gave a brief account of the nature and structure of *Bolopora*.

Continuing up the road, a small quarry in coarse dolerite, which was formerly notable as yielding good samples of epidote, was briefly inspected. Owing to overgrowth, conditions are no longer good for collecting. On the further side of the dolerite, altered rhyolitic tuffs were seen in small road-cuttings. From this point there was a good view towards the eastern side of the Craig-y-Castell and neighbouring intrusions, of which the further side had been seen from the Gwynant Valley.

At the road junction of Rhyd-wen a deviation was made across the peaty hollow along the line of the Ceunant Fault. Professor Cox indicated the great repetition caused by the fault, which here throws Ffestiniog Beds against Arenig rhyolites. At Bryn Rhug Farm some time was spent searching the material from a small trial in the highly pyritous black shales of the Dolgelley Beds and a good number of fossils were obtained, once the difficulty of breaking the rock obliquely across the cleavage was surmounted. Some of the bedding planes are almost covered by specimens of *Parabolina spinulosa* and *Orusia lenticularis*.

Returning to the Cader Idris Road the party continued to Llyn Gwernan, where the Director indicated some of the features along the straight fault-valley with its U-shaped profile. The head of this lateral valley could be seen in the distant notch of Ffordd-ddu, and the Director explained that the valley had been twice breached by transverse streams, once by the Gwynant and again by the Arthog stream. Heavy driving rain led the party to seek shelter in the former Llyn Gwernan Hotel, now being used as a Ministry of Supply hostel. Lunch was taken during the enforced wait.

The weather clearing slightly, members started up the Cader Idris path. The Director explained that the path commenced by following approximately the junction of the Arenig Lower Acid Group with the overlying Llanvirn (Bifidus Beds), but the strike was abnormal owing to the effect of the large dolerite intrusion of Mynydd Gader. Crossing a small hollow due to a transverse fault, a good exposure of flow-banded rhyolites in the Arenig Series was examined. A short distance beyond these rhyolites a coarse conglomerate was seen to dip away from the rhyolitic rocks and to pass beneath shales and ashes of the Bifidus Beds. This conglomerate, full of pebbles of volcanic rocks, seems to act as a local base to the Bifidus Beds. Shortly beyond the outcrop of the conglomerate the path leads over a peaty hollow marking the outcrop of the Bifidus Shales. From a suitable view-point the Director traced the outcrop of these shales from the Crogenen Lakes, across the Gwynant Valley, and through the nearby Penrhyn-gwyn slate quarry, and he indicated how, owing to complexities resulting from intrusions and faults, the Penrhyn-gwyn outcrop lies quite out of line from the outcrops in the Gwynant Valley.

The party then proceeded to Llyn-y-Gafr, making a short halt to examine a small exposure of pillow lavas below the path near the lake. Wind and rain and the fancied attractions of the mountain above, prevented most of the party examining the thick development of pillow lavas and associated ashes on the slopes between Llyn-y-Gafr and Llyn-y-Gader.

Some of the party, including Professor Cox, now returned to Dolgelley, while the remainder under the guidance of Professor Lewis ascended to Llyn-y-gader. This lake is held up by a moraine within a corrie cut in the precipitous scarp of Cader Idris. The lake lies on the outcrop of the lower part of a great intrusive sill of granophyre, while blocks of this rock, derived from the upper part of the sill, which forms so conspicuous a part of the scarp above, were seen to constitute the bulk of the morainic material. The lake waters seep through the loose material of the morainic dam, there being no other outlet. The Director explained that the sill was intruded into the Llyn-y-gader Mudstones. The cloud was well below the top edge of the escarpment, so it was impossible definitely to make out the upper junction of the sill with these mudstones, but the southerly dip of the beds back into the corrie and the fine columnar jointing of the granophyre were distinctly visible. The manner in which the columnar structure of the sill had facilitated plucking by ice and weathering was discussed ; the sill obviously controls the nature of the scarp face and corrie walls at this point. It was observed that the debris from the scarp-formed screes, and east of the lake a cone or corrom had been produced by a small stream at the foot of Foxes Path, the stream normally flowing towards the lake, but occasionally emptying on the other side of the cone.

Owing to the very unfavourable state of the weather, the party reluctantly but wisely decided to abandon the attempt to ascend to Pen-y-gader by way of Foxes Path and, through driving rain and rapidly descending cloud, turned downhill. A short detour from the path brought the party to the top of the escarpment overlooking Llyn-y-gafr. Here an exposure of massive felspathic ash, within the lower part of the Llyn-y-gader Group and underlying the granophyre sill, was examined, while below the ash the lower part of the Llyn-y-gader Mudstones was seen to crop out. At the base of these mudstones members were able to collect specimens from the band of oolitic and pisolitic iron ore, which forms so useful a mapping horizon in the Cader Idris country. After reference to Dr. Pulfrey's[1] work on these pisolitic rocks and indicating the mainly pyroclastic character of the underlying rocks of the Lower Basic Volcanic Group in this upper part of the scarp, the Director led the party back to the path below the Llyn-y-gader moraine, and little time was lost in returning to headquarters and tea.

Monday, August 28th, 1944.

Directors : Professor A. H. Cox and Professor H. P. Lewis.

CORRIS AND ABERLLEFENNI.

The party left Dolgelley at 10.40 a.m. by bus to Corris. Rain, mist and a crowded bus, prevented the scenic features and the results of river capture along the Talyllyn Fault line from being seen to the best advantage. Leaving the volcanic rocks behind at Talyllyn Lake, the route to Upper Corris crossed the wide outcrop of the Ceiswyn Beds (approx. Lower Bala), cleaved mudstones which do not yield good slates. At Upper Corris the Upper Bala rocks succeed and the road thence to Corris passes a continuous series of slate quarries, cutting yards and spoil heaps. Members commented on the immense amounts of waste slate in the tips.

Rain fortunately ceased as the party started the 1½ mile walk from Lower Corris to Aberllefenni. The Director indicated that the road follows a strike valley with the highest Bala Beds on the north side, Lower Valentian rocks in the floor of the valley, and Upper Valentian (Tarannon) on the opposing slopes. At Aberllefenni heavy rain drove members to shelter in the cutting sheds, where lunch was taken while awaiting resumption of the afternoon shift. The methods of cutting and smoothing were then inspected, by kind permission of Mr. T. O. Williams, Manager of the quarries. The management had kindly arranged for some large blocks to be available to demonstrate the methods of breaking along the cleavage, and then along the direction of " pillaring."

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[1] Pulfrey, W. "The Iron-ore Oolites and Pisolites of North Wales," *Quart. Journ. Geol. Soc.*, vol. lxxxix (1933), p. 401.

The slate from the Aberllefenni quarries is of high quality and is specially valuable for the preparation of very large slabs for electrical switch-boards and for acid-resisting vats. Most of the material is at present going to help the re-equipment of the devastated industrial plants in the Ukraine. Members examined the large finished slabs which, since the slates are well laminated, show very clearly the relation of cleavage to bedding.

A move was then made to the quarries. Professor Cox outlined the local succession in the Bala Beds as determined by the researches of Professor W. J. Pugh. The vein here worked is the " Narrow Vein," 60 feet thick. The bedding is nearly vertical and the outcrops are well displayed on the valley sides. A repeating fault could be seen to cause repetition of the outcrops on the west side of the valley, but not on the east. Owing to the steep dip the slate " vein " is worked by means of a series of huge underground chambers. Some of these chambers are over 200 feet long, 60 feet wide, and with heights up to 300 feet or more. Members then entered the lower level and examined one large chamber which was partly open to daylight, and another one which was entirely underground. The Director reminded members that legally all slate workings, whether open or underground, are " quarries," there being no such thing as a slate " mine."

The party returned to the entrance and ascended the hill in order to enter a higher level which afforded a further view of the large partly-open chamber previously seen from below. It had been intended to continue along the level right under the mountain and to emerge in the next valley, the Ceiswyn Valley. But the level was temporarily blocked by development work so the party had to return to the nearer entrance and then to walk around the mountain instead of through it.

At this point Professor Cox and two or three other members returned to Dolgelley by the direct route from Aberllefenni by way of Fron-fraith and the Aran Glen, and Professor Lewis conducted the rest of the party over the spur of Upper Bala rocks into Nant Ceiswyn.[1] Here the outcrops of the Bala and Valentian rocks could be seen clearly in the brilliant sunshine to strike across the valley to the north-east, for the differences in lithology are reflected by corresponding variations in the topography. The Director drew attention to the belt of high ground to the west and north-west, including Mynydd Ceiswyn and Waen Oer, composed of the Ceiswyn Beds in great thickness, and followed by a hollow marking the position of the soft mudstones of the Nod Glas at the top of the Lower Bala. Then the Upper Bala began with rough ground,

[1] PUGH, W. J., *Proc. Geol. Assoc.*, vol. xlvi (1935), p. 422.

indicating the Abercwmeiddaw Beds (including the Broad Vein), separated by a hollow, on the outcrop of the Red Vein, from a belt showing a number of old workings on the Narrow Vein. Seen end on from the south-west, the ridge made by the outcrop of the resistant Garnedd Wen Beds above the slate veins stood out prominently, all the more so as it was backed by the hollow occupied by the Lower Valentian rocks, which, in turn, passed up into rocks of later Valentian age to form a scarp on the east.

After a halt to inspect the opening in the Narrow Vein through which the party would have regained the surface, had it been possible to continue underground from Aberllefenni, the walk was continued northwards along the path on the western side of the Ceiswyn Valley, descending the succession obliquely to an outcrop of the Nod Glas near a tributary stream flowing south-east to join the Ceiswyn just south of the reservoir south of Ratgoed Hall, The soft, dark blue and occasionally pisolitic mudstones exposed at this locality are crowded with graptolites at certain levels and the members collected numerous specimens of *Dicellograptus*, *Orthograptus* and *Climacograptus* in situ and from loose blocks.

During the return to Aberllefenni and Corris, members were impressed by the fine drift terraces which occur at about 360 feet near Aberllefenni and 250 feet at Corris. After a hastily consumed tea at Corris the party returned to Dolgelley by bus.

Tuesday, August 29th.

Director : Professor H. P. Lewis.

CELYNOG VALLEY AND CRAIG-Y-FFYNNON (ARAN RANGE).

After rising with the dawn the party left Dolgelley by the 7.45 train for Wnion Halt and arrived soon after 8 a.m. Near the halt, the Basement Beds of the Ordovician, consisting of tough flags, siltstones and felspathic ash, were seen in the bed of the Afon Wnion below the road-bridge and were examined in the cutting on the northern side of the main road from Bala to Dolgelley. The Director explained that the actual base of the Ordovician is not seen, but that the Tremadoc slates are faulted against the Basement Beds, as shown by sections exposed in the Wnion and its tributary the Celynog.

Returning south of the bridge, the Brithdir road was followed along the strike of the Llanvirn mudstones to an exposure near Pont Sêl on the Afon Celynog. Here graptolites were collected from three levels of the Llanvirn. The lowest somewhat slaty beds yielded *Cryptograptus* cf. *tricornis* ; in the middle division of typical, pyritic, blue-black mudstone, with thin ash-bands, graptolites of the *Didymograptus bifidus* group were common, while an unidentifiable diplograptid was obtained from the uppermost, tough, calcareous flags which crop out on the roadside near the bridge and contain dendroids (? *Aspidiograptus* cf. *minor*). Some members of the party attempted to investigate the veins of calcite and rhodocrosite in the shattered rhyolitic ash exposed in the bed of the stream under the bridge, but the stream was too full to enable this to be done successfully, although the presence of some faulting at this point was obvious.

As the party climbed upstream along the right bank of the Celynog in the rain-soaked undergrowth, the steepness of the slopes gave good evidence of postglacial rejuvenation. Following the shattered ash above the bridge came a slaty ash, succeeded in turn by a massive felspathic ash giving rise to a small waterfall. These pyroclastic rocks, referred to the Lower Agglomeratic Group (Lewis, Brit. Assoc. Report, 1936), are followed by mudstones which have yielded poorly preserved glyptograptids and may be of Llandeilo age. They were searched in vain for fossils on this occasion. The next exposures examined higher upstream consisted of alternating bands of fairly massive felspathic ashes, thin mudstones and vesicular spilitic rocks forming the Middle Agglomeratic Group. Mudstones, in places agglomeratic, were seen to intervene between this group and the sheared, crushed and shattered rhyolitic ash which crops out at the old ‘ Roman ’ road-bridge. This ash is brought by the Bala fault against Tremadoc rocks (*Asaphellus* Flags) to the south in the valley-section. The rejuvenation in the Celynog valley was shown to have extended as far back upstream as the old bridge, at about 650 feet above sea-level.

Leaving the valley-section, the members proceeded to the north-east, approximately on the line of the Bala Fault, until the solid rocks south of the drift-covered fault-line began to be exposed, first, coarse dolerite forming a sill near Lletty-hên and, farther on, Tremadoc flags within the National Forest. This being a suitable view-point and the visibility being unusually good, the Director drew attention to the marked influence of the Bala Fault on the topography, the trend of the fault being conspicuous as valley or hollow all the way from Llanuwchllyn in the north-east to the Tal-y-llyn Valley in the south-west. The Director also pointed out the general distribution and structure of the Upper Cambrian rocks forming the lower slopes of the Arans in the country to the north-east and brought by the Bala Fault against the Ordovician rhyolitic rocks which form the prominent crags on the slopes of Bryn Hir north of Drws-y-nant. Professor Miller called attention to the platform features displayed on each side of the Wnion Valley and put forward tentative explanations to account for them.

The party then ascended a narrow path leading E.S.E., and exposures of an intrusive rock resembling hornblende-porphyrite were examined in the upper part of the Tremadoc flags. Eventually the Arenig rocks were reached near the western boundary of a large hilly sheep-walk named Bryniau Gwynion. The actual unconformable junction with the Cambrian was not seen, but only a few feet of unexposed rock intervened between the outcrop of

Tremadoc rocks and the line of small exposures of coarse, siliceous grit which marks the horizon of the 'Garth Grit' at the base of the Arenig Series. This grit, of which nearby loose blocks have yielded *Bolopora undosa*, was seen to be followed by the typical, streaky flags of 'Extensus Flag' type, passing up into a considerable thickness of massive, green-weathering, felspathic ash, which, in turn, was succeeded by the Aran Boulder Bed. This bed, which the Director observed had been mapped by Professor Fearnsides, Dr. W. H. Wilcockson and himself throughout the whole length of the Aran Range, is typically composed of boulders of "felsite," set in an ashy matrix. The felsite of the boulders is comparable to the rocks forming the Moel Ddu intrusion, which cuts the Ffestiniog Flags at Drws-y-nant. On leaving the exposures of the Boulder Bed on the crest of Bryniau Gwynion, advantage was taken of the clear view of the country to the west to discuss the general structural and topographical features. The party then descended over the outcrop of a large dolerite sill to an exposure of tough, blue-grey flags in the Afon Celynog at the southern corner of the Bryniau Gwynion field. Search was made for fossils, but none was forthcoming, despite the fact that *Ogyginus* sp. and dendroidea, suggesting a Llanvirn age, have been obtained from these rocks some three hundred yards to the south-west.

The next walk was to the east across the peaty hollow which lies south-east of Bryniau Gwynion and is traversed by a dip-fault which shifts the outcrop of the Tremadoc-Arenig junction southwards, on its eastern or upthrow side, for over a third of a mile. The party lunched on the hillside immediately above this junction where the flaggy Arenig basement beds are well exposed. After lunch the majority of the members climbed the steep slope of Bryn Mawr and examined the excellent weathered section of the Arenig, consisting in upward sequence of typical 'Extensus Flags' with rare pebbles, green felspathic ash with slaty and silty bands and containing a sill of 'andesite' near the top, and, passing up over the crest of Bryn Mawr, a fine development of the Aran Boulder Bed. The bedded character of the latter, several distinct boulder-beds alternating with ash with few or no boulders, the irregular arrangement of the boulders with their long axes often making high angles with the bedding planes, and the large size of the boulders, some being over two feet in length, were some of the features pointed out to the few members who visited the unique outcrop in the crags on the crest of the hill (see Pl. 3, Fig. A). In this area the highest part of the Boulder Bed is a platy ash containing a few scattered boulders, and it is succeeded by a dark pisolitic mudstone, the outcrop of which forms a hollow up which the party climbed the western flank of Bryn Mawr. This mudstone is possibly of Llanvirn age and appears to thin out eastwards.

As time was short, the rest of the sequence exposed on the steep slope of Craig-y-Ffynnon was covered as expeditiously as possible. Minor scarp features overlooking the hollow made by the mudstone consisted of banded, flinty, rhyolitic ash and a considerable thickness of rhyolitic agglomerate, which the Director suggested might represent the Lower Agglomerate Group. Scarps higher up the hillside were found to consist of compact and well-jointed sills of dolerite intruded into mudstone, which, in places, was altered to hornstone. Higher still, where the slope became steeper, pillow-lava, with good spheroidal masses with radiating cracks and vesicular crusts, was exposed, while farther east an instructive section showed ash followed by thin spilitic dolerite sills cutting with irregular junctions through slates, with which they were evidently approximately contemporaneous. After traversing a thick band of agglomeratic and rhyolitic ash up a stiff slope, the party reached the slate trial near the top of the main escarpment west of Glasgwm. No fossils were found in the belt of slates which crops out here. Farther to the east several specimens were collected of a fresh-looking flinty rhyolite showing perlitic and porphyritic textures and well-exposed above the slates near Llyn-y-fign.

On Glasgwm (2,557 feet), the summit lake of Llyn-y-fign was observed to occupy a rock-basin having no inlet, and draining southwards to the Afon Dyfi. Most happily the weather and visibility had continued excellent and a grand view was obtained of the surrounding country, stretching from the Lleyn Peninsula and Snowdonia to the Breidden Hills and the Drygarn country and beyond. The most conspicuous topographical feature was the high, dissected plateau of Central Wales, sloping gently away to the south-east. As there was no time left in which to visit the ironstone workings at Tyllau Mwm, which could be seen in the distance on the slopes leading up to Aran Mawddwy, the direct route from Glasgwm, over crag and torrent, swamp and wall, was followed by the party to Drws-y-nant Station, where the last members arrived just in time to board the train arriving at Dolgelley at 4.30 p.m.

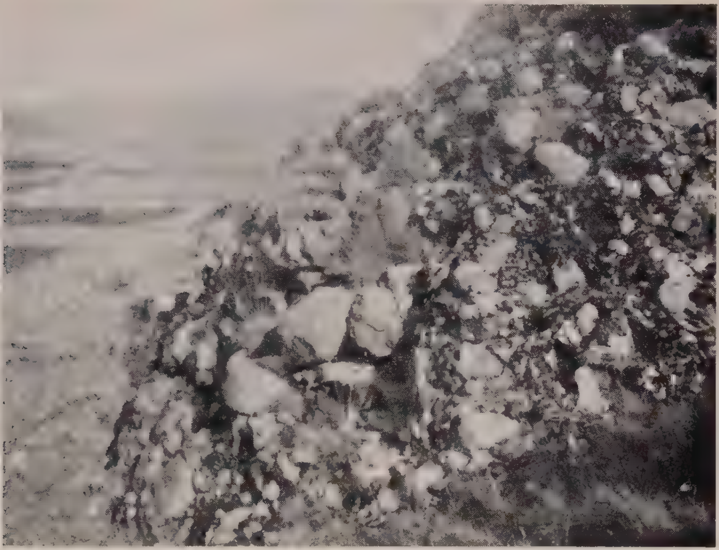
Wednesday, August 30th, 1944.

Director : Professor A. H. Cox.

GWYNFYNYDD GOLD MINES.

The party left Dolgelley at 9.30 a.m. by bus to Ganllwyd in the Mawddach Valley. Whilst waiting for cyclist members to arrive, the party examined the Clogau Shales underneath the main road bridge over the Gamlan stream. The Director then gave an account of the geology of the immediate neighbourhood.

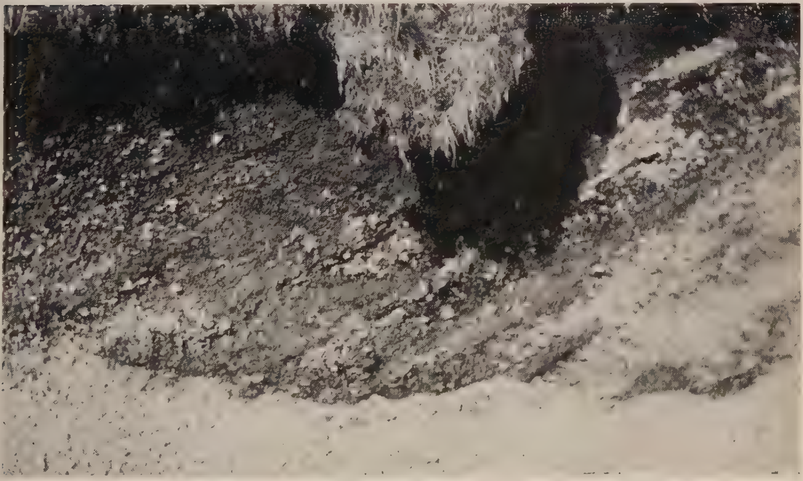
Proceeding through the village the party diverged from the main Trawsfynydd road, crossed the Afon Eden, and followed the track up the Mawddach Valley, passing through an extensive National Forest. Unfortunately the picturesque river scenery is being rapidly concealed by the forest growth. This part of the Mawddach Valley lies on the strike of the Maentwrog division of the Lingula Flags. Farther upstream the strata gradually bend round and large hornblende-porphyrite intrusions strike across the valley, confining the river to a deep gorge. Members searched



[*Photo by E. A. Midgley.*

A.—ARAN BOULDER BED, BRYNIAU GWYNION.

Boulder bed at the top of the Arenig Basement Series on the crest of Bryniau Gwynion, Brithdir Wchaf. The irregular arrangement of the 'felsite' boulders, their rounded form and the absence of grading are characteristic features.



[*Photo by H. P. Lewis.*

B.—DELTAIC FORE-SET BEDS, NANT HELYGOG.

Section of deltaic fore-set beds, with a cover of loamy clay on which vegetation is growing. Tributary of Nant Helygog. The deltaic beds were probably formed by a stream entering a high-level glacial lake.

[*To face p.* 74.

fallen blocks for the large porphyritic hornblende crystals which occur in places. Beyond these intrusions the valley is cut through Clogau Beds, well exposed along the river, but all appearing to be unusually massive, presumably owing to thermal metamorphism.

At Tyddyn-gwladys the Director indicated the spoil heaps from the Tyddyn-gwladys lode on one side of the river, and from the Cwm Hesian lode on the other side, while from the road-side a level had been driven along a vertical fault cutting the Clogau Beds with associated intrusions. The gently dipping and hardened Clogau Beds were examined in the road section. Further into the hill a quartz vein developed along the fault and a number of stopes had been driven up the vein. The neighbouring river section (by the sheds of the old Tyddyn-gwladys mine) showed a small intrusion, bordered on both sides by steep faults, but no quartz vein.

Continuing up the valley, members examined a curious dyke-like offshoot from a sill in the Clogau Beds. Baked sedimentary and chilled igneous rocks are so like one another that the junction needs careful search. This dyke is possibly a feeder to the sill above. It has forced the river and consequently the whole valley to make a sharp turn.

Shortly beyond, the party arrived at the picturesque waterfall, Pistyll Caen. The fall was initiated by a porphyrite intrusion in gently dipping Gamlan Beds, but the stream has now cut back and entirely severed the intrusion, the two halves being found on the hill-sides high above the fall. The lithology of the Gamlan Beds was examined and the narrow little ravine below the fall, with its clear illustrations of control by jointing, aroused comment. The Director indicated a small patch of bare rock in a streamlet at the south side of the road bridge. The rocks expose the core of a pitching anticline, but dips off the flanks are so gentle that the fold is only apparent on careful inspection from a favourable viewpoint. The pitch is much clearer than the folding. Although so inconspicuous, the fold is the dominant structure of the area and controls the dips over distances of a mile on each side of the fold axis. The existence of a fold axis at this place had already been postulated from the mapping of a quartzite band at the base of the Clogau Shales.

Nearby are the remains of the old Gwynfynydd 60-stamp mill which ran for many years, also the ruins of a new mill, built about 1935 which, owing to faulty construction, was unfortunately burnt down on the first day of operation. The party viewed the neighbouring fall, Rhaidr Mawddach, caused by an intrusion. The immediate surroundings have not been improved by mining operations. In a road-cutting near the fall members examined a white quartzite which here forms the local base of the Clogau Shales. No similar bed is known at the corresponding horizon in the Barmouth area. Continuing along the road, attention was called to an exploratory level driven along a fault separating shales and a small intrusion. The river section shows the shales to be unaffected by contact action thereby proving the existence of a fault. Beyond this point the river showed a continuous section of Clogau Shales dipping gently away from the Pistyll Caen anticline. The beds yield Menevian fossils, but time did not allow of search on this occasion. Farther on the director indicated the position of a sharp contact, apparently a fault, between Clogau Shales and Lingula Flags. There is no suggestion of transition at this point. The fault is one of a belt which displace the Gwyn lodes, as seen later in the mines.

Continuing along the road to its termination at the entrance to No. 5 level of the Gwynfynydd mine, the party then proceeded along the hillside noting in the stream below a beautiful columnar sill causing a small waterfall. Both contacts are well exposed. Levels by the fall have proved a large lode which the Director considers must be the continuation of the Gwynfynydd lode. A little farther upstream the lode strikes across the river and is well exposed, giving an exceptional opportunity to study a large lode in the open. Parts of the lode were seen to be highly brecciated and contaminated by fragments of more or less completely digested country rock. Brecciated material of this type was usually considered by the miners as more likely to be profitable than the parts composed of pure white quartz. On the south bank the lode was formerly extensively worked for lead. Farther east newer exploratory workings on a different set of lodes were visible. Beyond this was a hollow carrying a large transverse fault which apparently forms an eastward termination to all the lode outcrops.

Returning to the lower entrance to Gwynfynydd mine, members collected minerals from the spoil heap ; galena, blende, chalcopyrite and iron pyrites are all abundant and many other minerals have been recorded. Most of the party then entered the mine, seeing the characters and disposition of the lode, its faulted western termination and the manner in which the lode splits to enclose large horses of country rock. Various passages were explored and members then scrambled up one of the stopes and gained a remarkable impression of the immense amount of material that had been taken out, for the stope was seen to extend some hundreds of feet along the strike, and downwards at a dip of about 50° for 100 or 150 feet to drainage level, below which the workings are known to extend to a vertical depth of 165 feet below present water level.

Leaving the mine the party ascended the hill by way of an old incline and entered the short top level to the Williams' lode. The Director explained that owing to a fault belt running approximately parallel to the incline, the relation of these higher lodes to the Gwynfynydd lode below was not known. This upper level led to a big open cut showing a very thick quartz vein cutting Clogau Shales. Stopes leading down from the floor of the open cut showed that only the lower part of the quartz had been mined, the remainder being presumably relatively barren. A side passage was explored showing the vein terminated eastwards by a fault in the Clogau Shales. Other passages have explored this fault for a considerable distance.

On the neighbouring hillside a series of levels and open cuts exposed another lode, the Collett lode, with an intrusion apparently thrust over the shales which carry the lode. The return path led over the open hillside with good views of the matured types of slopes above the 800 feet contour and the maze of deep gorges below. A steep descent then led down to the road by Rhaidr Mawddach fall, whence the road was followed down the Mawddach Valley to Ganllwyd. Tea was taken at the beautifully situated Tyn-y-groes hotel overlooking a particularly picturesque stretch of the Mawddach. Some members found time to pay a brief visit to the fall of Rhaidr Ddu on the Gamlan river a few minutes' walk above Ganllwyd. From Tyn-y-groes the party returned by bus to Dolgelley.

After dinner Professor A. A. Miller gave members a short account of his observations on some of the physiographical features of the district, with special reference to the existence of relicts of a 200-feet platform on some of the hill-sides above the Mawddach Estuary, and to the presence of a series of valleys which probably denote overflow channels formed when the main Mawddach Valley itself was occupied by ice. An interesting discussion followed.

Thursday, August 31st, 1944.

Director : Professor A. H. Cox.

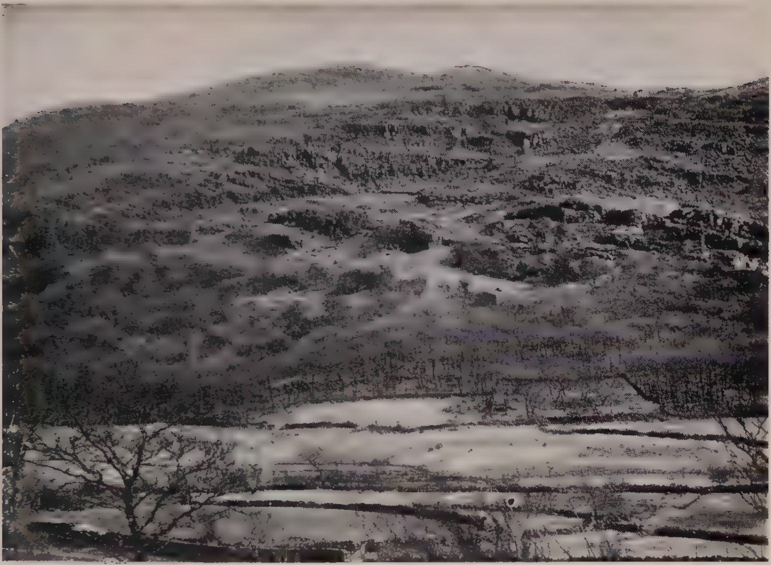
DIPHWYS AND BONT-DUU.

The party travelled by train to Penmaenpool and then walked across the bridge. At the lower end of the Cwm Mynach Valley, where the stream debouches on the alluvial flats, Professor Miller showed the remarkable results of a recent flood due to a cloudburst on May 29th, 1944. The pool at the foot of the waterfall, previously about 8 feet deep, was filled with coarse shingle and boulders and reduced to about 2 feet in depth. Coarse debris, including fragments of the concrete pipes of a small hydro-electric power installation, were seen spread over the adjacent meadows in a fan of nearly 100 yards radius. It was clear that the waters had risen above the old Miners' Bridge and damage had been done to the structure, but the main arch had stood firm. In the course of a few hours the river appears to have accomplished more work as a geological agent than it had done in the previous 100 years, since the old Miners' Bridge was built. Ascending the hanging valley to the bridge at Llwyn Tryfor, Professor Miller demonstrated further examples of the torrent's activities in destroying the bridge and the road which leads up the valley. The river at this point is just entering the rejuvenated gorge and is shut in by close growing-trees. Flotsam lodged in the branches showed that the water-level must have risen some 12 or 15 feet above the bouldery river-bed. A new and deep channel had begun to be carved out of the banks above the reach of normal waters, and boulders, measuring up to 6 feet in diameter, had been moved along the bed. Professor Miller hopes to publish in the near future a full account of this noteworthy occurrence.

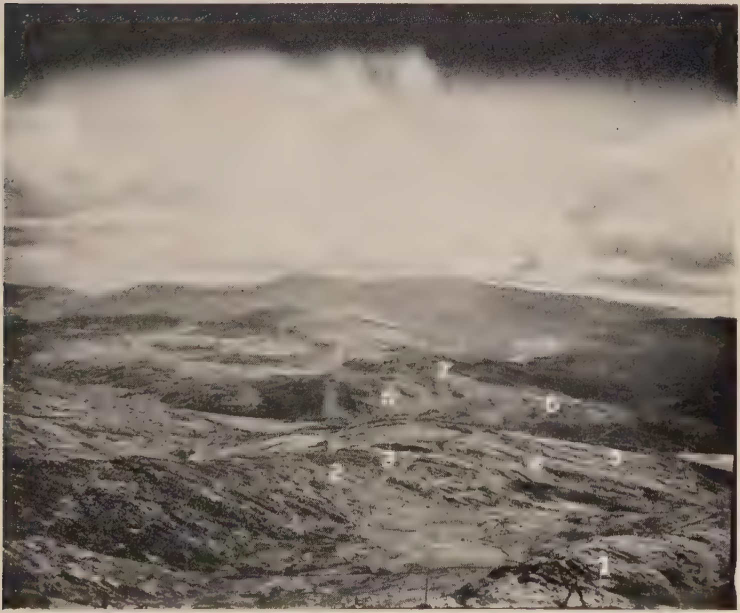
The rejuvenated tract of the valley in which this flood damage is apparent, is cut across the Maentwrog division of the Lingula Flags. From a view-point above the rejuvenation, Professor Cox indicated the crop of the Clogau (Menevian Shales) forming a belt of smoother and more fertile ground marked by numerous evidences of former gold mining. Beyond this tract the much rougher ground made by the Harlech Series made a marked contrast. Continuing up the Cwm Mynach, fine views were obtained of magnificent sections of the well-bedded grits of the Harlech Series, revealed on the hill-sides (Pl. 4, Fig. A), the scenery being closely comparable with that found in areas of Torridon Sandstone. Still farther up the valley extensive morainic deposits were seen to hold up the waters of Llyn Cwm Mynach, situated in a particularly wild and desolate tract of country. A quarter mile below the lake the party turned up the rough slopes leading to Diphwys and sought the shelter of some small crags, where lunch was taken in bright sunshine, but with a cold wind.

By reason of the increasing gale members decided not to attempt the ascent of Diphwys, so a way was made among the lower Drags to the col leading down to the Cwm-llechwen Valley. From this point a good view was obtained of the succession of the strata on the eastern slopes of Diphwys, the contrast between the precipices made by the Rhinog Grits and the smooth grassy slopes of the Manganese Shales being specially apparent. Crossing to the west side of the upper boggy portion of the Cwm-llechwen, members examined material from old manganese workings in the Manganese Shales below the south-eastern shoulder of Diphwys. The ore was seen to be closely similar to that at Barmouth except that brightly coloured pink rhodocrosite bands are much more abundant in the Diphwys ore.

From this point a rough track was followed down the west side of Cwm-llechwen with good views of the features made by the succession of rock groups—Rhinog Grits to Maentwrog Beds—dipping steadily southward off the Harlech Dome (Pl. 4, Fig. B). During the descent the party were met by one or two heavy rainstorms driving up from the Mawddach Estuary, but fortunately of brief duration. Reaching the lower ground at the junction of the Cwm-llechwen and Hergwm Valleys the weather cleared and Professor Miller indicated the relation of the streams to the tectonic structure and discussed the positions to which rejuvenation had extended up the lateral valleys leading down to the Estuary. The main rejuvenation was seen to start by the road-bridge at 390 or 400 feet above O.D. Professor Cox then indicated the positions of the extensive workings on the Vigra and St. Davids lodes. Following a path down the east side of the glen leading to Bont-ddu the gorge deepened rapidly. At the entrance to the St. Davids



A.—Y GARN (2,063 ft.) FROM CWM MYNACH.
View looking east. Scarps of Rhinog Grits form the lower slopes. The smoother slopes above the grit outcrop mark the Manganese Shale Group. Barmouth Grits form the summit of the mountain.



[Photos by W. E. Howarth.

B.—CADER IDRIS RANGE VIEWED FROM DIPHWYS.
View looking south. 1. Rhinog Grits. 2. Manganese Shales. 3. Barmouth Grits and Gamlan Beds. 4. Clogau Shales with sills and lodes. 5. Maentwrog Beds. 6. Ffestiniog Beds (south of the Mawddach Estuary, visible at extreme right). 7. Tremadoc Slates.

Mine the St. Davids lode is well exposed. The lode is here nearly vertical with hanging wall made by a small porphyrite intrusion. Large scale vein-brecciation is well displayed in the roof of the entrance tunnel, inclusions of black and metamorphosed Clogau Shale showing clearly against the white quartz. The St. Davids lode is stated[1] to have yielded 114,300 ozs. of gold between the years 1861 to 1907, giving an approximate value of nearly £450,000, and thus to have been the richest lode in the district. Neighbouring dumps were examined for minerals. Sulphide minerals are, however, not nearly so abundant as at Gwynfynydd.

Continuing down the glen the site of the old stamp-mill, worked by water power and active in 1904, was briefly inspected. The original stamp-mill was completely dismantled, but a small pilot mill for small scale tests was erected when a new company started prospecting about 1935.

A short walk brought the party to Bont-ddu, where tea was obtained at the Half Way Hotel. After tea a walk of a little more than a mile along the main road led the party to Penmaenpool, thence by train to Dolgelley.

Friday, September 1st.

Director : Professor H. P. Lewis.

BONTNEWYDD TO BWLCH OER DRWS.

The party reached Bontnewydd by the train leaving Dolgelley at 10.40 a.m. The first features of interest to be noted were the terraces cut in the glacial drift by the Afon Wnion at heights of approximately 5, 10, 20 and 30 feet above the river and conspicuous near the station. The Director pointed out an exposure of dolerite on the north side of the main road and north of the Ceunant Fault, which here lies beneath the valley alluvium. The party then crossed the Wnion Valley and followed the Brithdir road until, south of Ty-croes-isaf, dark blue, pyritous slates of Upper Cambrian (probably Dolgelley) age began to crop out on the roadside on the southern slope of the valley. From this point to Llwyn Talcen the route did not strictly coincide with the original programme, as the party kept to the Brithdir road and then came to its objective by way of a lane leading south-east. Throughout this distance all the exposures were of dolerite, usually a coarse, ophitic rock, belonging to a large sill, mainly drift-covered, which obscures the nature of the Cambrian-Ordovician junction in this area. Professor Miller discussed with other members the positions and relative significance of the different platform features which are so well displayed in this region, and which were crossed near Dolserau Terrace and near Pentre-pen-y-gareg at heights approximating to 400 and 600 feet respectively.

Between Llwyn Talcen and Gorwyr highly cleaved, dark blue and grey-blue, pyritic, slates were searched for fossils without success, but graptolites of the *D. bifidus* group have been found in these beds about half a mile west of this locality. These sediments are succeeded by members of the Lower Agglomerate Group, which are exposed in the lane east and south-east of Gorwyr in a region affected by dip-faulting. The section showed green-weathering ash, in places containing ' felsite ' boulders, and with steep and possibly reversed dips, slaty felspathic ash and pale slate with dolerite intrusions. In the fields forming a sheep-walk farther to the east, ashy rocks, including a massive felspathic ash, are succeeded by a pillow lava which gives a narrow outcrop forming a prominent ridge on which the party sat for lunch. These ashy and spilitic rocks belong to the Middle Agglomeratic Group. Tough, striped and banded flags and ash were observed to separate the spilitic rocks from streaky rhyolitic ash, which is the only solid rock here exposed in the drift-covered area up to the line of the Bala Fault.

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[1] ANDREW, A. R.—"The Dolgelley Gold Belt," *Geol. Mag*, 1910, p. 206.

After crossing the marshy hollow occupied by this fault and noting on its further side an intrusion of green weathering hornblende porphyrite rich in epidote, the party ascended the succession of Cambrian and Ordovician rocks exposed in the Nant Helygog. Near the Bala Fault, Tremadoc rocks with thin intrusions were noticed. Next came the Arenig Basement Beds, including greenish weathering felspathic ash containing a thick development of the Aran Boulder Bed. The Arenig rocks are here strike-faulted against the Upper Cambrian slates, but a breccia with fragments of Garth Grit aspect occurring in the fault, visible in the stream bed, shows that the unconformable base of the Arenig is at no great distance below the surface.

A thick, transgressive sill of coarse dolerite, which forms prominent glaciated crags on the hillside north-east of the stream, cuts in above the Boulder Bed and can be followed in the stream section until exposures end under a drift cover. Higher upstream, at the sheepwashery, agglomeratic mudstones of Lower Llanvirn age are exposed, and a few yards higher still members collected *Ogyginus corndensis* from tough, blue, calcareous flags. Mr. W. Smith secured a specimen of a large *Conularia*. The Director pointed out that the fauna so far obtained at this locality, including Didymograptids of the *bifidus* group from the lowest bed, points to equivalence with the Llanvirnian of the Llandrindod and Shropshire areas.

From this point, after visiting an outcrop of the Lower Agglomerate (platy and rhyolitic ashes) in the stream section, a detour to the east was made to examine some *roches moutonnées* shaped out of a development of the same group, but containing large boulders of ' felsite,' and so forming a second, local, boulder bed *above* the Llanvirn flags. The Director suggested that the wide and fairly flat-topped spread of alluvium which occupies this portion of the upper Helygog valley from about 1,100 to 1,150 feet, had probably been deposited, in part, as a delta in a small lake dammed back by ice flowing from the east and north-east, as shown by *roches moutonnées* and overflow channels. After traversing the outcrop of the Middle Agglomeratic Group (slates, ash and spilitic rocks with intrusions of dolerite), the party was conducted to a section of the alluvium cut by a tributary of the Nant Helygog. In this, although the surface-cover of loam had slumped over the lower beds and tended to obscure the section, a rhythmic and probably seasonal deposition of the underlying layers of alluvium was seen to be strongly suggested by their arrangement and grading. Each layer began with coarse shingle and graded up into clay at the top. The layers averaged about six inches in thickness and dipped downstream as the foreset beds of a delta, being truncated upwards by the superficial layer of loamy clay (Pl. 3, Fig. B). Small waterfalls in this tributary were observed to be due to the presence and cutting back of harder layers of iron pan in the less resistant alluvial deposits.

From this section the party climbed the ridge overlooking the pass of Bwlch oer drws, and the sight of the Dinas Mawddwy-Dolgelley road below induced the majority of the members to walk at once to Cross Foxes to secure tea ; others walked back to Dolgelley, while one or two stayed with the directors to examine the succession on the northern side of the pass and to collect specimens of a fine felspathic and agglomeratic ash and of an unusual nodular rhyolite. The topographical and structural features, including the anticline at Craig Buarth Glas, brought out by differential weathering of the volcanic rocks and the succeeding Bala mudstones, were observed in the valley leading to Dinas Mawddwy. The return to Dolgelley was made by bus, arriving at 6 p.m.

After dinner a vote of thanks to the Directors was proposed by Dr. G. W. Himus and seconded by Mr. E. Nuttall. The Directors replied briefly, and then Dr. Raw and Professor Miller were called upon for speeches. Finally a spokesman for the ladies was selected by drawing names from a hat. This concluded a very pleasant meeting which, except for the one day on Cader Idris, was favoured by exceptionally fine weather for most of the time. The following morning the majority of members dispersed, while a few stayed on to make further acquaintance with the area.

THE PRIMARY AND SECONDARY ELEMENTS OF A FOLD.

By JOHN CHALLINOR, M.A., F.G.S.

[*Received 3rd February,* 1944.]
[*Read in Abstract, 2nd December,* 1944.]

I. INTRODUCTION.

IN analysing a fold, it may be useful to recognise two sets of elements: those that are essential, or primary, and those that appear, as it were, secondarily by virtue of the " setting " of the fold in relation to the earth's surface. We can then distinguish between, on the one hand, the geometrical form of the fold and the intensity of the forces needed to produce it and, on the other hand, the particular attitude of the fold and the direction and location of these forces. It need hardly be said that a fold is not to be thought of as being actually produced in two successive stages.

The whole matter is a very simple one, but perhaps not quite so obvious that it can be taken entirely for granted. It is, moreover, fundamental in the study of folds, and appears to be almost entirely neglected in works on structural geology; though Busk (1929, p. 6) does remark that the plane of the horizon is a purely conventional plane of reference. For these reasons the writer ventures to offer the following short discussion.

II. " AXIAL PLANE " TERMINOLOGY

It is necessary to comment, in the first place, on some points of terminology in connection with the " axial plane."

The precise meaning of this term is not quite settled, though it is always realised that there is some fundamentally important, more or less imaginary, surface within a fold. Indeed, the search for the most appropriate definition of " axial plane " is the search for the exact placing of the first and foremost of the primary elements of a fold.

The most thorough discussion, known to the writer, of the " axial plane " is that by Busk (1929). He first defines it as follows (p. 7): " The axial or apical plane of a fold is a surface so disposed within it, that any point upon that surface is equidistant from either limb of the fold, as defined by any particular horizon." But later on (p. 55) he shows that such a surface does not generally exist in incompetent folds; but that there is nevertheless usually a definable *surface within the fold bisecting the regions of maximum curvature in successive horizons*. In competent folds this is also the " axial plane " as first defined; and it thus seems that a preferable definition for " axial plane " would be that just given, which would apply to both competent and incompetent folds. Further, the present writer would favour the adoption of

" axial surface " for " axial plane," and he proposes to use that term in this article.

A short discussion of fold terminology has been given recently by Hills (1940, pp. 71-3), and this seems to the writer the most satisfactory interpretation so far proposed. Hills nevertheless adopts Busk's first, and narrower, definition of the axial surface ; and moreover reproduces a series of diagrams from a previous author's work (fig. 52), in which the " axial plane " seems to have some meaning not usually implied. This all goes to show the confusion that still surrounds the term. Also, there appears to be room for some emendations in the terminology of certain important lines in the axial surface.

" Apex " is defined by Hills as " the line along which the axial plane of a fold intersects the upper surface of any particular bed in the fold." But the term suggests a point and not a line : and it is particularly inappropriate for use with a syncline, although the definition does not preclude such a use. A term thus seems to be required for the line which may be defined as Hills defines it, but without the word " upper," which is in any case unnecessary ; and one equally suitable for an anticline or a syncline. Then " axial line " is defined as the intersection of the axial surface with either the horizontal or the ground surface, and thus has two meanings ; and this term would be equally suitable for the " apex."

The following usage is therefore proposed : the intersection of the axial surface with a bedding surface to be the *axial bedding-line*, its intersection with the horizontal the *axial strike-line* and its intersection with the ground the *axial ground-line.*

Each of these is a line in space, but each has a plan-position ; that is, a projection on to a horizontal surface. It may also be mentioned that axial bedding-lines are " crests " or " troughs " only where the axial surface is vertical or, where the axial surface is inclined, if the fold is definitely an anticline or a syncline and is sharply bent.

Throughout this article it will usually be convenient to visualise a single fold, rather than the series of folds of which this fold would normally form a part.

III. ENUMERATION OF PRIMARY AND SECONDARY ELEMENTS.

The primary elements of a fold appear to be :—

1. The form of the axial surface.
2. The degree to which the fold, in any of its parts, is competent or incompetent.
3. The acuteness of the folding, or the degree of compression of the fold.
4. The size of the fold ; that is, the lengths of the limbs.

The secondary elements will then be those given by :—

1. The dip and strike of the axial surface.
2. The direction, up or down (or sideways), of convergence of the beds ; that is, whether the fold is anticlinal rather than synclinal, or vice versa.
3. The position, with respect to the earth's surface, of any line in the axial surface, that is definable apart from the " setting " of the fold. An axial bedding-line would be such a line.
4. The position on the map of any point in the axial surface (if the place where the fold occurs is taken to be one of its elements).

The strikes and dips of beds in the various parts of the fold are, of course, secondary elements.

IV. VERTICAL, AND NORMAL, CROSS SECTIONS

Apart from the projection of outcrops on to a horizontal plane (that is, a plan or map) and, if necessary, the " correction " of this so as to show a truly horizontal section, a fold is usually considered in a vertical cross section. Now these two sections are, from several points of view, important when the fold is " set " ; but in relation to the fold itself in its essential form, the vertical section, even in a selected direction, has no very special significance, and the one possible " direction " for a horizontal section has no significance at all. To exhibit the primary elements of a fold as clearly as possible, the sections required are not the horizontal and a vertical in relation to the earth's surface, but those in the two planes at right angles to each other and to the axial surface, and at the same time normal and parallel respectively to the axial bedding-lines within the fold.

Of the two sections just mentioned, the first is much the more significant, and certainly seems to require some distinctive name. Perhaps to call it the " normal cross section " would serve to distinguish it from the " vertical cross section." The word " normal " would then be understood to be in respect to the axial bedding-lines themselves, and the word " cross " to refer to any plane of which the strike is at right angles to the plan-positions of the axial bedding-lines ; the two words in this connection being likely to convey these meanings respectively (if the meanings be analysed). If preferred, the word " transverse " could be used instead of " cross." The other, complementary, section might perhaps be called the " normal longitudinal section."

These four sections are shown in Figure 3, and, expressed purely in terms of the lines to which they are respectively normal, may be enumerated again as follows :—

Vertical cross section
normal to the horizontal projections of axial bedding-lines.

Horizontal section
normal to vertical lines.

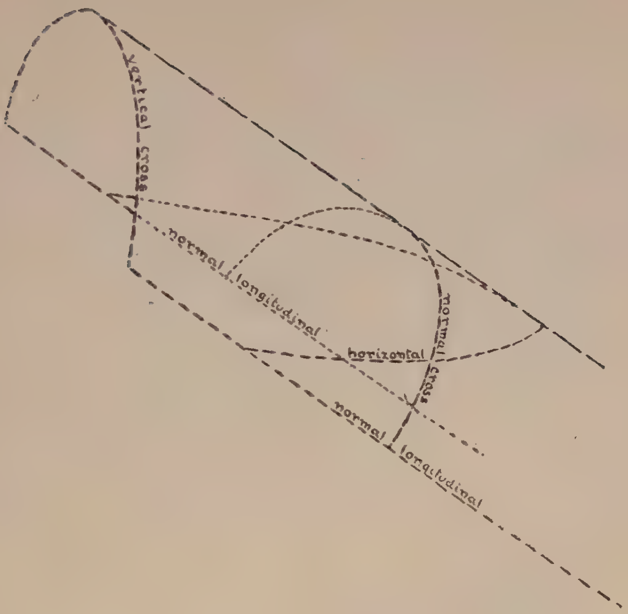

FIG. 3.—PLANES OF SECTION OF A FOLD.

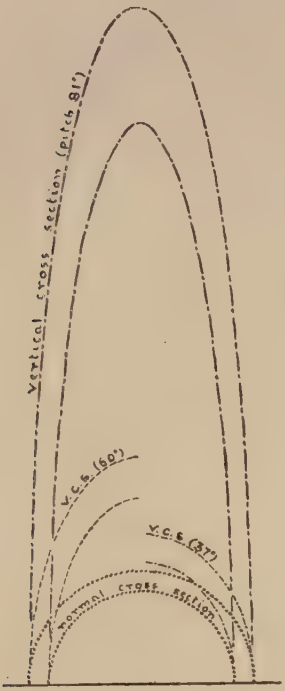

FIG. 4.—NORMAL AND VERTICAL CROSS SECTIONS.

Normal cross section
normal to axial bedding-lines
Normal longitudinal section
normal to trace-lines of the axial surface on normal cross sections.

In the special case of a non-pitching fold, the normal cross section and the vertical cross section are the same, as are the normal longitudinal section and the horizontal section.

If the axial surface is curved, these planes will change their directions correspondingly.

The writer would emphasise that the normal cross section is unique in being the only one which exhibits primary elements satisfactorily. For instance, one of its features is that in it the beds make maximum angles at the axis, and thus show the true degree of compression of the fold (Fig. 4). In so far as folds are likely to have any possible degree of pitch, the convergence of beds in a vertical cross section will not show the true compression any more than will the convergence in a horizontal section ; and it is never supposed that the angle of the " V," in the outcrop (on an approximately horizontal surface) of a pitching fold, is any measure of the degree of compression of the fold.

Then again, the normal cross section is the only section through a fold which shows, in all its parts, the true thicknesses of the beds ; nor will any other section show the correct constancy or variation in the thickness of a bed. This latter fact is of particular importance when the behaviour of the beds in the region of the axial surface is considered. In competent (parallel) folding, and where the beds are not sharply bent, there will be no thickening of the beds in the region of the axial surface. But a competent curved (pitching) fold will show apparent thickening of the beds, along the trace of the axial surface, in a vertical cross section. This is clear from Figure 4. A wrong impression as to the nature of the fold might therefore be drawn from a vertical cross section ; whereas the true state of affairs is shown, and shown only, in the normal cross section.

Another false illusion is also illustrated in Figure 4. A fold such as the semi-circular one there shown, may have no very particular axial surface within it, but an apparently definite axial surface is shown in a vertical cross section. If one of the limbs of this fold had been drawn shorter than the other, the plane bisecting the arcs, and which might be called the " axial surface," would not be the vertical apparent axial surface as seen in a vertical cross section.

A normal cross section may be drawn across a fold recorded on a map, by first drawing a vertical cross section in the usual way, and then projecting this section on to the plane of the normal cross section. This would assume that successive cross sections (vertical, normal or other) in parallel planes would be the same over short distances. Some method of simple proportion would effect the projection, as in Figure 5.

Owing to the fact that jointing is particularly liable to occur along planes approximating to those of normal cross section, such sections are apt to be by no means rare in nature.

The two meanings, a wider and a narrower, of " symmetrical " as applied to a fold are well understood, and have been briefly discussed by Hills (pp. 74-5). The wider meaning applies to a fold in its essential form ; if the fold has a plane of symmetry, then it is symmetrical, and the plane of symmetry will be the axial surface. The narrower meaning of symmetry applies to a fold when " set." The essentially symmetrical fold must then, to fall within this narrower meaning, have the axial surface vertical. These two senses of symmetry illustrate well the distinction between the primary and the secondary elements of a fold.

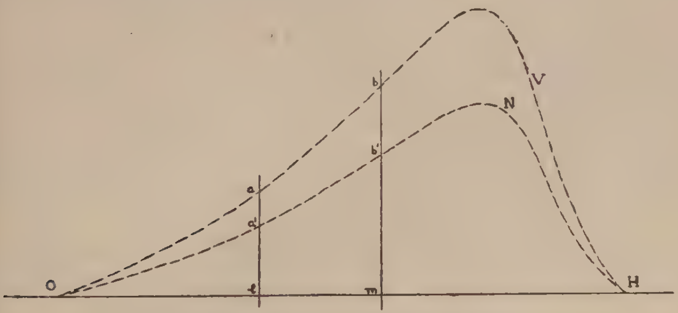

FIG. 5.—TRACES OF A BEDDING SURFACE.

V. THE QUESTION OF THE NATURAL DISSECTION OF FOLDS.

In conclusion, mention may be made of the question of the dissection of folds in natural exposures.

It is not proposed to go into this matter here ; though the theoretical points discussed very briefly in this article have been forced on the writer's attention while studying the folds which are exposed, in all manner of ways, in the cliffs and along the shore in the neighbourhood of Aberystwyth. Nevertheless, the question seems to be of some interest and importance, and one that is not so simple as might appear. It is very seldom alluded to. Dana (1875, pp. 97-8) gives a brief discussion, and as this happens to illuminate the present matter, it may perhaps be mentioned. The author makes an attempt (and very properly) to consider all possible sections across a fold, instead of confining attention to a few cases not particularly likely to occur in nature ; and he recognises, to some extent, the special significance of the normal cross section. But the discussion appears to go astray, with " dip " and " strike " taking on strange meanings, because (in the present writer's opinion) he fails to separate the primary, from the secondary, elements of a fold. Mention may also be made of a paper by Fisher (1881), which to some slight extent touches on the problem of the present article, and which led to a lively discussion at the time it was published.

The writer is indebted to Professor H. P. Lewis for drawing his attention to the above two references, and to Dr. G. D. Hobson for some very helpful suggestions on various points.

REFERENCES.

BUSK, H. G. 1929. Earth Flexures. Cambridge.
DANA, J. D. 1875. Manual of Geology, 2nd ed. New York.
FISHER, O. 1881. "Oblique and orthogonal sections of a folded plane." *Geol. Mag.*, pp. 20-23.
HILLS, E. S. 1940. Outlines of Structural Geology. London.

EXPLANATION OF FIGURES 3, 4 AND 5.

FIG. 3.

Sketch of a folded surface, showing one example of each of the four planes of section referred to in the text.

FIG. 4.

The pair of half circles shows a normal cross section of a bed of uniform thickness in a semi-circular parallel fold. The pairs of half, and quarter, ellipses show vertical cross sections of the same bed in three separate cases (as examples) :—when the fold pitches at 37° ($\cos^{-1} \frac{3}{4}$), 60° ($\cos^{-1} \frac{1}{2}$) and 81° ($\cos^{-1} \frac{1}{5}$) respectively. These show the apparent thickening of the bed in vertical cross section ; the greater the pitch, the greater the apparent thickening. They also show how, if misinterpreted, the degree of compression of the fold is falsified ; and, again, how the illusion of a definite axial surface is created. If the fold were taken as pitching at angles complementary to the above, the ellipses would show the respective horizontal sections.

FIG. 5.

Construction showing the trace (ON) of a bedding surface in normal cross section drawn from its trace (OV) in vertical cross section. OH is the horizontal. aa′l and bb′m being any two vertical lines cutting OV, ON and OH as shown,

$$\frac{a'l}{al} = \frac{b'm}{bm} = \cos \alpha$$

where α is the angle, between the planes of the normal, and vertical, cross sections. The figure was drawn on squared paper in the first place.

GEOLOGY IN EMBRYO (UP TO 1600 A.D.)

By C. E. N. BROMEHEAD, B.A., F.G.S.

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ALDROVANDUS of Bologna died in the year 1605; in his will, quoted from Fantuzzi by Adams in his book *The Birth and Development of the Geological Sciences*, he mentions a packet of papers labelled "Geologia ovvero de Fossilibus." This appears to be the first use of the word Geology in the accepted sense; it was not adopted by his pupil Bartholomaeus Ambrosinus who published, in 1648, the "Musaeum Metallicum of Aldrovandus," presumably based on the papers mentioned in the will. It is, however, convenient to take the year 1600 A.D. or thereabouts as that of the birth of Geology. The following paper deals with geological observations and ideas prior to that date.

It might be thought that the subject had been sufficiently covered by such well known authors as Lyell, Geikie, Zittel and H. B. Woodward; but it will be shown that many passages have been left unnoticed which indicate either some geological theory or the general acceptance amongst non-scientific writers of such ideas; also that certain comparatively well known passages have been misinterpreted or wrongly attributed.

It is only natural that such striking geological phenomena as earthquakes and volcanoes should receive frequent description and varied attempts at explanation; but allusions to fossils are surprisingly frequent and of great interest. Ancient mineralogy consists mainly of descriptions, often somewhat bewildering, of ores and precious or semi-precious stones, but traces of scientific mineralogy gradually emerge. The present writer has dealt elsewhere with the early history of two aspects of practical geology, mining and water supply, but something will be said here of quarrying.

With trifling exceptions we are dependent at first on the surviving literature of Greece and Rome, and, for genuine scientific thought, almost entirely on the former. Aristotle stands out supreme as one of the greatest, if not the greatest, of all men of science throughout the ages; of him Richard de Bury wrote "For not even Aristotle, although a man of gigantic intellect, in whom it pleased Nature to try how much of reason she could bestow upon mortality, and whom the Most High made only a little lower than the angels, sucked from his own fingers those wonderful volumes which the whole world can hardly contain. But on the contrary, with lynx-eyed penetration he had seen through the sacred books of the Hebrews, the Babylonians, the Egyptians, the Chaldeans, the Persians and the Medes, all of which learned Greece had transferred to her treasuries." To this fourteenth century reference we may add a remark from a modern scientific writer: "The basis of Aristotle's method, as set out in his writings, was the ascertainment of facts by actual observation of natural phenomena." (Lones). With Aristotle we may couple his pupil Theophrastus, to whom we owe the first mineralogy. Strabo, who calls himself a geographer, is also an outstanding figure in science ; his own ideas entitle him to a seat among the great, and we also owe him a tremendous debt for the preservation of important passages from his predecessors. But a number of geologically interesting points can be culled from writers with no claim to be called men of science. We are apt to think of Plato as an idealistic, not to say dreamy, philosopher ; but an important passage on the effects of deforestation, etc. is quoted below ; on the strange attractive power exerted by amber and the Heraclean stone (the original name of magnetite) he remarks that there is no physical pull (the word used—ὁλκή—means towing), but to one who *investigates methodically* (τῷ κατὰ τρόπον ζητοῦντι —a fine definition of a scientist) it is clear that these things "exert a circular pulsion on one another" ; the verb used, περιωθεῖν, is even more suggestive of a field of force than Prof. A. E. Taylor's translation of the Timaeus. Again, several geological statements will be given from Plutarch, a biographer and essayist. The geology of the Greeks, imperfect, of course, but surprisingly good relative to the contemporary knowledge of the other sciences with which it is linked, was a part of the general culture ; such a statement could hardly be made today. On the contrary, knowledge of and interest in geology seems somewhat lacking even amongst professedly scientific men. The best English authority on the history of Science is probably Charles Singer, but his interests are mainly in Medicine and Botany ; in his "Short History of Science" he gives no reference to fossils before the middle of the seventeenth century ; he devotes nearly a page to Theophrastus as a botanist, but does not mention his book on stones, the earliest systematic treatise on mineralogy. In his contribution to "Science, Religion and Reality," Singer remarks that the year 1600 really does mark a turning point in the history of science as a whole, thus justifying both this paper and its limitation. Sarton has published a great "Introduction to the History of Science," of which Volume I—to Omar Khayam in the second half of the 11th century—occupies 783 pages without the "brief index." The latter gives only three references under "geology," and in the text these do not amount altogether to half a dozen lines. To be fair, the geological enquirer can find considerably more to interest him, but geology is certainly treated, here and generally, as a Cinderella amongst her sister sciences. It is an object of this paper to reveal her in her ball dress.

Of Latin writers the nearest approach to science is to be found in Lucretius, but he hardly touches on geology and pays a striking tribute to Greek thought (iii., 1-13, trans. W. E. Leonard) :

> O thou who first uplifted in such dark
> So clear a torch aloft, who first shed light
> Upon the profitable ends of man,
> O thee I follow, glory of the Greeks,
> . . . . our father
> And finder-out of truth.

It is hard to include Pliny the Elder as a man of science. His "Natural History," or "History of the World," is an exceedingly interesting collection of statements, factual and fanciful: in some of the latter he does, it is true, express disbelief, while others equally ridiculous are accepted. For instance, from his account of the "diamond" (adamas) it is to some extent possible to guess the identity of the various minerals included (see below); but when he says that the diamond can only be dissolved in the blood of a freshly killed goat and wonders who first made this discovery and how he came to test it in the blood of the filthiest of beasts—"surely it must have been by divine inspiration"—the spirit of "methodical investigation" seems sadly lacking. One of his 17th century editors, Gronovius, notes that the experiment had been tried, but was a failure! It is worth recording that within about sixty years of his death a non-scientific writer, Aulus Gellius (x, 12) criticised Pliny for including many foolish and intolerable absurdities (*vana atque intoleranda*) tales of ridiculous nonsense (*deriducalae vanitatis*) and so on and attributing them falsely to Democritus.

It is a familiar cliché that the Greek genius was theoretical, the Roman practical: the second part of the statement is certainly true. The Greek language was continued by the Byzantine Empire, but little scientific thought appears. Greek thought centred in Hellenistic and later times in Alexandria, where the Museum was founded by Ptolemy; the Serapium library lasted till 390 A.D. and the main library till the Arab conquest in 640. From Greek through Syriac and Arabic the tradition passed back into Latin in Spain and so to Scholastic Italy in the 12th century; the later Renaissance was a period of labour in which the old knowledge struggled to the birth of our science.

GENERAL GEOLOGY IN CLASSICAL TIMES.

Cosmology, where geography, geology and astronomy meet, need not be discussed at length; Prof. E. G. R. Taylor has recently dealt with the subject in an Historical Association Pamphlet. The discovery that the earth is, roughly, spherical, goes back to Babylonia and was generally accepted in Greece by the sixth century B.C. Strabo (i, 3, § 3) draws attention to a point which is only too apt to be forgotten even by geologists, the relative insignificance of the irregularities which are all-important in the eyes of the microcosm, man: "Eratosthenes goes into a description of the figure of the earth: . . . . . he proceeds to tell us that the earth is sphaeroidal, not however perfectly so, inasmuch as it has certain irregularities; he then enlarges on the successive changes of its form, occasioned by water, fire, earthquakes, eruptions and the like; all of which is entirely out of place, for the sphaeroidal form of the whole earth is the result of the system of the universe, and the phenomena which he mentions do not in the least change its general form; such little matters being entirely lost in the great mass of the earth. Still, they cause various peculiarities in different parts of our globe, and result from a variety of causes."

Before speaking of these peculiarities and their causes we must confess that the idea of a sphaeroidal earth was to prove too strong meat for many. Pliny had his doubts ; a passage from Plutarch is quoted (without fuller reference) by Prof. Taylor : " We must not heed the philosophers when they try to refute paradox with paradox . . . . and what absurdities do they not put forward ? Do they not say that the earth is spherical . . . that it is inhabited by Antipodes, who crawl, like worms and lizards, upside down " ? I am by no means sure that this is fair to Plutarch ; the passage is from a dialogue on " the Face appearing in the Moon," and is certainly introduced by the words " I said to him." But the beginning of the dialogue is lost ; it is not certain that Plutarch is himself the speaker, in fact the only modern translation I have seen (Prickard) attributes the " I " sections to his elder brother, and the whole thing may well be an elaborate skit on " philosophical debates." A passage on the formation of Egypt quoted below seems more significant of Plutarch's own outlook. The sphaeroidal earth was recognised by the poet Ovid, who says (Fasti vi, 269-271) that it is like a ball and is kept poised in mid-air by its own rotation, and continued to be accepted by thoughtful people for many centuries ; e.g., St. Augustine (died 430 A.D.) says that it may be a matter of scientific proof (*aliqua ratione monstretur*) : he does not think that any antipodes (i.e., *men* living at the opposite end of a diameter to ourselves) exist, pointing out quite logically that it is a mere assumption that there is land, not ocean, there, still more so that such land is inhabited by men (De Civitate Dei, xvi, 9). It is a pity that Augustine did not deal with more questions of a scientific nature ; when discussing the lodestone he carefully classified the evidence—" I have related what I myself have witnessed : I have related what I was told by one (previously named) whom I trust as I trust my own eyes : let me further say that I have read," this last being a popular fallacy (*ibid.*, xxi, 4). Again when giving a list of natural marvels, he says that he has been careful to select, not events that happened once and are over, but matters of fact which anyone, if he has the will and opportunity, can verify for himself. Several Greek men of science were persecuted in the name of religion ; we are familiar with the opposition of the Church to scientific progress at the Renaissance ; it is often forgotten that between the two periods it is to the Fathers of the Church that we must turn to find a scientific attitude of mind. It is not entirely lacking even in that extraordinary writer Cosmas Indicopleustes : he was a Greek monk of the 6th century, uneducated but far travelled, who wrote a book mainly directed against the idea of a spherical earth. His theory was based on the delusion that the Tabernacle of Moses and the Table of Shewbread were a scale-model of the universe. Yet this flat-earth enthusiast visited Ethiopia, India and Ceylon and gave excellent first-hand descriptions of the fauna, which he illustrated with accurate drawings ; most of the animals he had seen, several he had eaten ; but beneath the drawing of a unicorn he wrote " This beast I have never seen, so I give a drawing based on brazen statues." Such honesty inspires confidence.

The irregularities of the earth's surface seem to some extent to have been taken for granted ; there is little discussion of the origin of mountains, which Pliny calls the skeleton of the earth or regards as a framework to "restrain and keep within bounds that unruly element, the water," by confining rivers in the intervening valleys ; there is little about subaerial denudation, though, as we shall see, the deposition of alluvium was accepted as a commonplace. Considerable changes in the distribution of land and sea were, however, accepted from the time of Pythagoras : in Pindar's Olympian Ode VII (464 B.C.) we are told that when the rest of the land was already in existence the island of Rhodes was still beneath the sea ; "from the waters of the sea arose an island, which is held by the father of the piercing beams of light. Zeus that rulest over the height of Atabyrium . . ." We must not expect exact science in an ode to celebrate a victorious athlete, but Atabyrium is a mountain 4,070 ft. in height. Aristotle (Met. I, 14), mentions that areas that were sea have become land and vice versa and adds the important statement that "we must suppose these changes to follow some order and cycle" (τάξις and περίοδος). Strabo even mentions (I, 3, § 5) "the upheaving or depression of the strata on which the waters rest" as the cause of changes, and argues that small scale action which can be observed is a guide to the greater that can be inferred. The argument that much that is now land was once sea is, of course, based largely on fossils, discussed below. Even the poet Ovid has something to say on the matter (Metam. XV) :

> Even places alter—with uncertain gales
> Where once was land the bounding vessel sails
> And where the sea once spread, on steady land
> Now houses, trees and men securely stand.
> Shells far from sea removed are often found
> And anchors buried in the mountain ground.
> Torrents a valley of a plain have made
> And mountains headlong to the sea conveyed.

He then gives several examples, including islands now joined to the mainland and new islands cut off from it.

The great example of the formation of new land is naturally the Nile Delta, mentioned by Aristotle (Met. I, 14, § 10-12, 26-28) and many others. The relevant passage from Herodotus may be quoted, especially for its introduction (ii, 5). "It is evident to a man of common understanding, who has not heard it before but sees it, that the part of Egypt which the Greeks frequent with their shipping is land acquired by the Egyptians, a gift from the river ; and the parts above the lake, during a three days' passage . . . are of the same description. For the nature of the soil of Egypt is of this kind ; when you are first sailing to it and are at the distance of a day's sail from land, if you cast the lead you will bring up mud and will find yourself in eleven fathoms of water : this shows that so far there is an alluvial deposit." The delta is later compared with similar deposits in the plain of the Meander and elsewhere, and our author then indulges in a remarkable speculation (ii, 11), "If the Nile were to turn its stream into the Arabian Gulf, what could hinder it from being filled with soil by the river within twenty thousand years? For my part I think it would be filled within ten thousand. How, then, in the time that has elapsed before I was born, might not even a much greater bay than this have been filled up by such a great and powerful river?" Almost immediately after he mentions the occurrence of (fossil) shells in the *mountains* of Egypt as proof that the land was once sea presumably before the Nile existed. This is a near approach to a geologists' conception of time; we may contrast it with Catcott's "proof" that all the mountains in the world were produced by denudation when the waters of Noah's flood subsided into the interior of the earth in the year 2349 B.C., less than two thousand years before Herodotus wrote: Catcott's book was published in 1761 A.D.

Plutarch has a long passage on the same subject (Isis and Osiris): he mentions the mollusca (κογχύλια) found both in the mines and on the mountains as proof that all Egypt was once sea; but later the Nile formed the flat land by continual deposition of mud, "all of which hath the testimony of sense to confirm it. For we see at this day that as the river pours down fresh mud and adds new earth unto the old, the sea by degrees gives way and the salt water runs off as the parts in the bottom gain height by new accessions of mud. We see, moreover, that the island Pharos, which Homer observed in his time to be a whole day's sail from Egypt, is now a part of it: not because it changed its position or came nearer the shore than before: but because the river still adding to and increasing the main land, the intermediate sea was obliged to retire." It would be strange if the author of these remarks was genuinely sceptical about the spherical form of the earth. The filling up of the Sea of Azov (Palus Maeotis) by the Don is also mentioned several times; Aristotle (Met. i, 14) says that "the limit to the size of the ships which can now sail into it to trade is much lower than it was sixty years ago." Polybius (IV) says much the same and their remarks might well be transferred to Kent nearly two thousand years later. He then remarks that time is infinite; even the Black Sea is limited and therefore it, too, will eventually be filled up with mud by the rivers: but he gives no hint as to the backward extension of time.

It is strange how little notice was taken of the complementary subject, the erosive action of rivers. The Vale of Tempe was popularly supposed to have been formed by the rending apart of the sides by an earthquake (Herodotus and others) and a similar origin was ascribed to the Straits of Messina. Almost the only genuine note is struck by Polybius, essentially a military historian, who says (iv, 70) that the town of Psophis is rendered secure and difficult of approach by the deep ravine which the stream, impassable in winter, has gradually worn for itself in the course of ages. Servasius, a 4th century A.D. poet, says that cascades hollow out the scurfy tufa (scabrum tofum), an apt though peculiar description. There are several allusions to the plain of La Crau near the mouth of the Rhone. Here is a Pliocene bed of pebbles 17 to 20 metres thick; large pebbles of quartzite stand out abundantly at the surface, with finer material preserved below. Aeschylus gave a mythological explanation—the stones were sent from heaven to serve as missiles on a particular occasion—a sure proof that the phenomenon attracted attention ; Aristotle thought they were thrown up by an earthquake and ground against each other ; Posidonius attributed them somewhat vaguely to wave action in a former inland sheet of water. Strabo, who records the above opinions, hints at ideas nearer the truth (iv, 1, § 7) ; he compares these stones to both river-gravel (κάχληκες ποτάμιοι) and beach-pebbles (ψῆφοι αἰγιαλίτιδαι); it is for the same reason that all are smooth and of uniform size. In view of this paucity of observation and inference it is the more remarkable that the Jewish writer, Philo, arguing that the earth cannot have existed from all eternity (Eternity of the World, cap. xxiii) says that the action of rain-drops, torrents and rivers would in the course of ages have smoothed and levelled the whole earth ; or in more modern language, that the final stage in aerial denudation is a peneplain.

On the origin of the springs which give rise to the rivers Aristotle reads like an up-to-date text-book and gives the lie to absurdities, some of which have not even yet been eradicated from popular parlance ; they can mostly be traced back to Pliny, who records such delusions as glibly as the cheapest 20th century press. In Meteorology (i, 13 : 349B) Aristotle writes " We must not suppose, as some do, that rivers have their source in definite subterranean lakes : on the contrary, the water, derived from rain, trickles together little by little " ; he appeals to observed facts in support of his views : " when men construct an adit (ὑδραγωγία) they collect the water in pipes and trenches (350A), as if the earth in the higher ground were sweating the water out " ; he also uses the analogy of a saturated sponge ; a site transmits the water it contains by gradual percolation of many drops (350B). " It is true, as we learn from rivers that are swallowed up, that chasms and cavities and (φάραγξ and διάστασις) do exist in the earth, but only under special conditions (351)." I suspect that he could have stated the " special conditions " with some approach to accuracy. In the De Mirabilibus he, or a member of his school, says (58) : " In the same place [the island of Demonesus, Chalcedon] there is a cave which is called the Pretty Cave. In this pillars have been formed by congelation from the drippings of the water (κίονες πεπήγασιν ἀπὸ τινῶν σταλαγμῶν) and this becomes evident from their being contracted towards the ground, for the narrowest part is there."

Pausanias appears to have understood the formation of stalagmite, though he has no occasion to state a theory. He speaks (x, 32) of the Corycian cave between Delphi and Parnassus, which he regards as the best worth seeing of all the caves and grottos he had visited, many of which he lists : " It is larger and you can go a very great way through it even without lights . . . water is dripping from the roof, so that everywhere the marks of the droppings (ἴχνη σταλαγμῶν) are visible on the floor of the cave." Frazer's notes on this passage give a full description, including "the stalagmites rising from the floor and the grove of stalactites hanging from the roof and sides . . . it is like a fairy grotto." Again Pausanias mentions (iv, 36) a cave at Pylus " in which it is said the cows of Nestor and of Neleus before him were stalled." Frazer described it as follows :—" The stalactites do not hang free but cling to the walls in a variety of fantastic shapes. There can be little doubt that, as K.O. Müller first suggested, this was the cave where young Hermes was said to have stowed away the stolen cattle of Apollo. For the author of the Homeric *Hymn to Hermes* represents the cave as being at Pylus, and says that after Hermes had killed two of the beasts, he stretched their hides on the rock, where, the poet adds, they may be seen to this day. The stalactitic formations on the sides of the cave probably gave birth to the myth. See the *Hymn to Hermes*, 101-126, 397-404. The cavern, like the semicircular bay which it overlooks, is now called the Voidokoilia, " ox's belly ! " Mere mentions of caves as such are, of course, common in the poets ; Mela's text-book of geography includes (ii, 8) that in the Rock of Gibraltar (Calpe) .

Natural denudation is a perpetual, though usually a slow process : " man-accelerated denudation is what is now known as soil erosion " (Jacks and White). To this the aridity of many parts of the Old World is nowadays attributed, the cutting down of forests being one of the major factors. The subject has only become prominent in the present century : here is what Plato said about it in the fourth or fifth century B.C. (Critias, 111 ; Prof. A. E. Taylor's translation, incorporating some notes and correcting a misprint).

" Why are we right to call Attica as it now is a remnant of the land of those days ? It is one long projection running out from the main body of the continent into the open sea, like a headland, and, as we know, the marine basin that borders it is extremely deep. So, while there have been many formidable deluges in the course of the nine thousand years—that is the interval between the date we are speaking of and the present—the soil washed away from the higher levels in these periodical convulsions does not deposit a noticeable sediment, as in some other regions, but is regularly carried off and lost in the depths. . . . At the time we are speaking of our present mountains (ὄρη = bare rocks and crags) were high crests (γηλόφοι ὑψηλοί = hills covered with soil), what we now call the plains of Phelleus were covered with rich soil, and there was abundant timber on the mountains, of which traces may still be seen. For some of our mountains at present will only support bees (i.e., are heather-clad), but not so very long ago trees fit for the roofs of vast buildings were felled there and the rafters are still in existence. There were also many other lofty cultivated trees which provided unlimited fodder for beasts (? pannage for swine). Besides which the soil got the benefit of the yearly water from Zeus (rainfall), which was not lost as it is today, by running off a barren ground to the sea ; a plentiful supply of it was received into the soil and stored up in the layers of non-porous potter's clay. Thus the moisture absorbed in the higher regions percolated to the hollows and so all quarters were provided with springs and rivers." Does that not cover the ground fully ?

EARTHQUAKES AND VOLCANOES.

Descriptions of earthquakes are very frequent in the classical historians and geographers and of volcanoes also in the poets. It is here only necessary to notice indications of definitely geological thought applied to them. Aristotle deals at some length with the causes of earthquakes ; his views have been summarised by Lones as follows :—" Up till his own time, Artistotle says, three different views about the causes of earthquakes had been put forth (Mete. ii, c 7, s 1). According to him, Anaxagoras believed that they were caused by the water of the upper regions bursting into the under parts and hollows of the Earth (ii, 7, 2). Democritus assumed that the Earth, already saturated with water and, in addition, receiving quantities of rain water became shaken thereby (ii, 7, 5). Anaximines believed that the Earth was shaken by masses falling in, such masses having been broken away during a process of drying the Earth, which he assumed to be quite moist (ii, 7, 6)." Setting forth his own views on earthquakes, Aristotle says that the Earth of itself is dry, but, on account of the rains, becomes moist, so that being subjected to the action of the Sun's heat and its own internal heat, a large quantity of a spiritous vapour (πνεῦμα) is generated both without and within it, and this vapour flows sometimes into and sometimes out of the Earth (ii, 8, 1). " For this reason earthquakes are more frequent and violent in calm weather. The violence of earthquakes, in so far as it is manifested in the destruction due to them, depends in no small degree on the character of the geological formations of the area of disturbance. Aristotle believed that earthquakes were more violent and also more frequent in districts where the land was porous or cavernous, or where the coast was much broken (II, 8, 8). He instances the Hellespontine territory, Achaia, Sicily and Euboea, where the sea appeared to flow into narrow passages under the Earth (ii, 8, 9)." It seems clear that the great scientist was by no means satisfied that his theory was complete ; can we say much more today ? Pliny (ii, 81-87) is content to say that earthquakes, which he described with many instances, are underground storms. Seneca devotes the whole of book VI of his " Quaestiones Naturales " to the subject ; the translation by Clarke with notes by Geikie is readily accessible. He discusses older opinions at length, and one can only make guesses as to his own, though he has many first hand observations of fact. He seems to consider air in the interior of the earth as the main cause, but is really concerned with a philosophical attitude to the events : why worry ? We must all die, and it makes no difference whether the cause is the fall of a pebble or a whole mountain. The very similar account by Lucretius (vi, 535 *et seq.*) is given in full by Adams.

Aulus Gellius, in his entertaining collection of table-talk (Attic Nights ii, 28) sums up the position : " What is to be regarded as the cause of earthquakes is not only not obvious to the ordinary understanding and thought of mankind, but it is not agreed even among the natural philosophers whether they are due to the mighty winds that gather in the caverns and hollow places of the earth, or to the ebb and flow of the subterranean waters in its hollows, as seems to have been the view of the earliest Greeks, who called Neptune 'the Earth Shaker'; or whether they are the result of something else or due to the divine power of some other god—all this, I say, is not yet a matter of certain knowledge." (Trans. L.C.L.) He goes on to describe how, when sacrifices were ordained on account of an earthquake, the victim was offered "to either the god or goddess," lest the wrong one be named.

Pausanias classified earthquakes, the most serious in their effects being those that are accompanied by an advance of the sea, as at Helice in Achaia in 373 B.C. He continues (vii, 24) "ominous signs foretell the approach of great and far-reaching earthquakes. The nature of the signs is generally the same. For earthquakes are preceded either by heavy and continuous rains or long droughts. The weather, too, is unseasonable. If it is winter the weather is sultry; if it is summer there is a haze and the sun's disc appears of unusual colour, slightly inclining either to red or dun. Springs of water mostly dry up. Sudden gusts sometimes sweep aross the country, blowing the trees down. At times, too, the sky is shot with sheets of flame. Stars are seen of an aspect never known before and strike consternation into the beholders. Moreover, a mighty murmur is heard of winds blowing underground. And many more signs there are whereby the god gives warning of the approach of violent earthquakes." With this list Frazer compares that given by Lyell. Thucydides gives several instances of tidal waves (iii, 89): "The cause, in my opinion, of this phenomenon must be sought in the earthquake. At the point where its shock has been most violent the sea is driven back, and suddenly recoiling with redoubled force causes the inundation. Without an earthquake I do not see how such an accident could happen." Strabo (i, 3) mentions the formation of new islands and the permanent engulfing of considerable areas. Tacitus describes the great earthquake in Asia Minor in 17 A.D. and says "quick flashes of lightning showed all the horrors of the scene (Annals ii, 47)." Demetrius of Callatis (quoted by Strabo, I, 3 § 20) noticed the interruption of the flow of distant springs, as occurred at Lisbon in 1755.

The classical literature on volcanoes is mainly concerned with Etna; until the preliminary rumblings of the great eruption of 79 A.D., which destroyed Pompeii and Herculaneum Vesuvius, had long been quiescent. The first recorded eruption of Etna was in 479 B.C. and is alluded to by Aeschylus (Prom. Vinct.). Thucydides mentions three since the Greeks settled in Sicily; he witnessed that of 425. Pindar's description (Pythian Ode I) of that of 475 is also from personal observation as noted by Aulus Gellius, who contrasts his description of an eruption with Vergil's; Pindar has more closely followed the truth and has given a realistic description of what actually happened there and what he saw with his own eyes . . . Vergil's is full of monstrous inaccuracies." (xvii, 10). But most of the relevant passages, both Greek and Latin, are given by Johnston-Lavis. The word "crater" (κρατήρ) is first used in this sense by Aristotle and adopted by Diodorus and Strabo. The former was a native of Sicily ; in Book xi, 27, he writes of the "great wonder there called the Craters" : these are "great hollows in the earth, not very large in compass but of incredible depth from whence break out great sparks of fire and burning liquid, as though from boiling chaldrons. The liquid cast forth resembles so many streams of fire ; but there is no knowing its nature, for no-one hitherto has even dared to approach it ; for the violent eruption of the fiery matter is so wonderful that it seems to be the immediate effect of some divine power. It smells like brimstone, and the bottomless gulf roars and makes a most dreadful and horrible noise. And that which is far more to be wondered at is this, that the river of fire neither flows nor makes any stay upon the ground, but in a continual motion, with an amazing force, hurls itself up into the air." Later (xiv, 7) he mentions an eruption of Etna when streams of lava reached the shore, and the army of Himilco had to make a detour round the mountain. The eruption of Etna in 126 B.C. is described by Orosius, an author whose history of the world to 416 A.D. is of interest to Englishmen as Alfred the Great translated it into Anglo-Saxon for the use of his people.

It has been claimed that one of the wall-paintings at Pompeii shows a view of Vesuvius. It is in the landscape background of a charming picture of Venus teaching Cupid to fish, and it certainly reminds us of the familiar outline of the cone ; that, of course, is proof that it has no connection with the mountain, of which, however, we have contemporary descriptions.[1] Plutarch (Life of Crassus) describes how Clodius besieged the gladiators "within a mountain, accessible only by one narrow and difficult passage, encompassed on all sides with steep and slippery precipices. Upon the top, however, grew a great many wild vines from which the gladiators made rope ladders and so got down to take the besieging force in the rear. It is only from other historians (Velleius Paterculus I, Florus III, 20) that we learn that the mountain was Vesuvius, which then consisted, not of the present familiar cone, but of the unbroken crater of which Monte Somma is the surviving part. Logan Lobley gives a drawing constructed from the available descriptions ; these need not be quoted here, except that by Strabo (v, 4 § 8) which includes a specifically geological observation :— "Mount Vesuvius is covered with very beautiful fields, excepting its summit, a great part of which is level and wholly sterile. It appears ash-coloured to the eye, cavernous hollows appear formed of blackened stones, looking as if they had been subjected to the action of fire. From this we may infer that the place was formerly in a burning state, with live craters . . . this may be the cause of the great fertility, just as the sides of Aetna are excellent for vines."

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[1] The most geologically interesting of these paintings, of which I am aware, shows two urchins escaping from a crocodile; the background beyond the river (Nile), as reproduced in colour by E. Presuhn (Leipzig, 1878) shows signs of approximately horizontal bedding in the bare rocks of the hills, with characteristic rectangular profiles. Another painting, more recently discovered, is said on good authority to represent the vegetation on Vesuvius, but I have seen neither original nor reproduction.

Silius Italicus says that, amongst other marvels, Vesuvius thundered like Aetna as a portent during the war with Hannibal (viii, 655), whereas the first signs of activity were in 63 A.D. But his poem contains several other notorious anachronisms. It is somewhat ironical that this comparatively little known passage, text and translation, appeared in the *Times*, 23rd March, 1944, under the heading " Old and True." Perhaps he was consciously using poetical licence, for at the end of his book (xvii, 593) he speaks of Vesuvius, at length mastered by some hidden force, vomiting forth to heaven the fires it has fed for centuries.

Amongst the most delightful writings in classical Latin that have come down to us are the letters of the younger Pliny : many translations are available and those describing the eruption of Vesuvius in 79 A.D. and the death of his uncle the naturalist are given in full by Logan Lobley. Less well known is the lengthy account by Dio Cassius (lxvi, 21). " In Campania remarkable and frightful occurrences took place ; for a great fire suddenly flared up at the very end of the summer. It happened on this wise. Mt. Vesuvius stands over against Neapolis near the sea and it has inexhaustible fountains of fire. Once it was equally high at all points and the fire rose from the centre of it ; for here only have the fires broken out, whereas all the outer parts of the mountain remain even now untouched by fire . . . Thus the entire mountain resembles a hunting theatre (i.e., an amphitheatre), if we may compare great things to small. Its outlying heights support both trees and vines in abundance, but the crater is given over to the fire and sends up smoke by day and a flame by night." His general description of the events of 79 gives all the familiar facts and some fancies concerning the appearance of the Giants on the ground and in the air. He speaks of the dust which buried Pompeii ; " indeed, the amount of dust, taken altogether, was so great that some of it reached Africa and Syria and Egypt, and it also reached Rome, filling the air overhead and darkening the sun. There, too, no little fear was occasioned, that lasted for several days, since the people did not know and could not imagine what had happened but, like those close at hand, believed that the whole world was being turned upside down, that the sun was disappearing into the earth and that the earth was being lifted to the sky." The same author gives a long description (lxviii, 24) of the earthquake at Antioch in A.D. 115, ending with the words " Even Mt. Cassius itself was so shaken that its peaks seemed to lean over and break off and to be falling upon the very city. Other hills also settled, and much water not previously in existence came to light, while many streams disappeared."

Several interesting points are to be found in Procopius, who described (vi, 18) the eruptions of 472 and 512 A.D., presumably from hearsay, as he says that Vesuvius lies north of Naples ; one point, however, is from first-hand knowledge—in any eruption a great quantity of ashes is thrown up ; " whenever it so happens that a strong wind springs up, the ashes rise to a great height, so that they are no longer visible to the eye and are borne wherever the wind which drives them goes, falling on land exceedingly far away. And once they fell in Byzantium (472 A.D.) and so terrified the people there, that from that time up to the present the whole city has seen fit to propitiate God with prayers every year." He adds that " whenever Vesuvius belches forth these ashes, the country round about is bound to flourish with an abundance of crops. Furthermore, the air on this mountain is very light and by its nature the most favourable to health in the world. And indeed those who are attacked by consumption (φθόη = phthysis) have been sent to this place by physicians from remote times."

Seneca wrote a letter (lxxix) to Lucillius, which all men of science might read with profit, on "The Rewards of Scientific Discovery" : "I shall have the boldness to ask you to perform another task, to climb Aetna at my special request. Certain naturalists have inferred that the mountain is either wasting away or gradually settling, because sailors used to be able to see it from a greater distance." He thinks both causes may be correct, but wants his friend to go and see. It has been suggested that the poem on Etna, included in old editions with the works of Vergil, but of unknown authorship, may have been the answer. It is chiefly remarkable for the scientific outlook of the enquiry, which summarily dismisses the mythological explanations. The cause of the eruptions is the air in the hollows of the earth, which, confined in narrow spaces, acts like the blast of a furnace : the nature of the fuel is indicated by the extensive deposits of sulphur and traces of bituminous matter, but above all the lava itself (*lapis molaris*), which fuses more easily than iron. When its heart is burnt out by repeated cooking it becomes pumice (*pumex*). The author mentions the region between Naples and Cumae where sulphur wells forth unceasingly—the Solfatara (ii, 431-33) and describes the small cone of eruption in the middle of the great crater of Etna, also mentioned by Strabo (vi, 2, 8). Vitruvius is mainly interested in the practical question of building materials and is quoted below.

There are also several descriptions of the Phlegrean Plain, so named according to Diodorus (iv, 1) " from a hill which anciently vomited out fire, like Aetna in Sicily, now called Vesuvius, which retains many signs and marks of ancient eruptions." The solfatara of Tmolus near Smyrna are described by Strabo (xii, 2, 11). Of the Lipari Islands Diodorus (v, 1) writes " The Islands called the Eolides are seven in number, by name Strongyle (Stromboli), Euonymus, Didyma, Phoenicusa, Hiera, Vulcania and Lipara . . . they have been all subject to great eruptions of fire, the passages of which, by the openings of the earth, are apparent and visible at this day. But in Strongyle and Hiera to this very time violent vapours burst out of the earth with a dreadful roaring noise ; abundance likewise of sand and fiery stones are vomited out of the ground, the like to which may be seen about Mt. Aetna." Posidonius (quoted in Strabo vi, 2 § 11) noticed the formation of a new islet—" the lava of which it is formed subsequently congealed into a rock like millstones." It may be recalled that the Niedermendig rock was already a favourite material for millstones. In section 6 of the same chapter he points out that volcanic action serves as a safety valve for the forces which cause earthquakes ; these have been frequent in Sicily and the islands when the volcanoes were quiescent, but ceased in times of activity. This connection, especially in Lipari, had previously been noted by Aristotle (Met. ii, 7 and 8). It may be worth mentioning that Philostratus (Imagines ii, 17) describes a large picture of a number of islands : they are not named, but are quite clearly the Lipari or Aeolian group. One is evidently Didyme, the Twins, described as two severed portions that would fit together ; they have been separated " by the width of a river," and are now linked by a bridge. The catastrophe is ascribed to an earthquake. " The neighbouring island, my boy, we may consider a marvel ; for fire smoulders under the whole of it, having worked its way into underground passages and cavities of the island, through which as through ducts the flames break forth and produce terrific torrents from which pour mighty rivers of fire that run in billows to the sea. If one wishes to speculate about such matters, the island provides natural bitumen and sulphur ; and when these are mixed by the sea the island is fanned into flame by many winds, drawing from the sea that which sets the fuel aflame. But the painting, following the accounts given by the poets, goes farther and ascribes a myth to the island "—that of the giant, still breathing fire, held down by the weight of the island placed upon him by Zeus.

FOSSILS.

Of all classical passages about fossils alluded to by modern writers the most frequent is from Xenophanes, a writer of philosophical verse of the 6th century B.C. and therefore our earliest authority. For several reasons it seems advisable to discuss it at some length. It is first (as far as I know) mentioned by Parkinson in 1804. He gives a reference that is correct, though it has been misunderstood by later authors—Xenophanes, Originis Philosophumena, Cap. xiv ; this would have been clearer as Xenophanes in the Philosophumena of Origen. No books by Xenophanes have survived and we know his work only from quotations ; but some geologists appear to have thought that the word Originis in the reference was part of the title of a book by him, as might be suggested by the subject, while one American writer is justly rebuked by C. R. Eastman for attributing the passage to an imaginary Origines with date 600 B.C. Origen was a Christian Father of the 3rd century A.D. Since Xenophanes wrote in verse it is reasonable to suppose that we have his statements ungarbled by the nine centuries of interval. In the middle of the 19th century a new and more complete manuscript of the book Philosophumena was found at

Mount Athos. From this it was clear that the previous attribution to Origen was wrong and that the book is almost certainly by his contemporary, Hippolytus. Let us now leave the question of authorship and look at the text, a translation of which should read as follows : " He (Xenophanes) said that the sea was salt because a large variety of mixed materials flows into it"—an intelligent remark at his date—" Further Xenophanes laid down that land and sea were mixed up ; the land is even thought to be dissolved in course of time by moisture ; he offers as a proof of this the fact that sea-shells are found in the midst of the earth, even in mountains. Again, that in the stone quarries of Syracuse remains of fish and a certain kind of seal are found ; while in Paros in the depths of the rock one finds impressions of sprats and in Malta even moulds of all kinds of marine creatures. He says that it follows from this that at one time all these lands were under water." The next few lines are doubtful, but one remark is clear—" the impression of the fossil has been dried out and consolidated [literally " made costive "] in the mud." For this translation I am largely indebted to Mr. G. W. Henderson, Sub-Librarian of St. Paul's Cathedral, who kindly lent me a copy of the rare *Editio Princeps*, Hamburgh, 1706, edited with Latin version and notes by Gronovius. I have also checked it against the modern text in Migne's Patrologia Graeca (Vol. xvi, pt. 3, 1863) which follows that revised by E. Miller (Oxford, 1851). The word for sea-shells is κόγχαι ; according to Aristotle (Hist. Anim. iv, 4) these are smooth-shelled bivalves, probably *Tapes*, *Mactra*, etc. : the word is also used for a brain-pan or knee-cap, but has no connection with *Patella* = Limpet, which is λέπας in Greek. The most important word is that here translated sprats, viz., ἀφύη. This is the reading adopted by Gronovius and accepted by all recent authorities. It is also used by Aristophanes for some of the purchases to be found in shopping baskets after going to market, and " sprats " or " whitebait " seems the best English equivalent, though the Italian " nonnati " or French (Marseilles) " nonnats " would be more accurate. It is safe to assume that Xenophanes alluded to the slabs with innumerable specimens of little fish of the genus *Prolebias* frequently found in the Oligo-Miocene of the Mediterranean region. But in place of " sprats " several modern geologists give " laurel leaves " ! Clearly this reading is irrelevant to the argument that sea and land have changed places. The Greek reading adopted in this case is δάφνη, involving only a minute difference in copying or reading a manuscript. It is noted, but rejected, by Gronovius ; but the Daphne is given by Dalechamps in a note on Pliny (xxxvi, 5) in his fine edition of 1688, so it has quite a respectable ancestry. Humboldt (Cosmos, vol. i, p. 264, of the Bohn translation) mentions both and upholds the sprats. The most accessible version of the Philosophumena (of Hippolytus) is a translation of the whole work as known from the Mt. Athos manuscript by F. Legge, London, S.P.C.K. 1921 ; it is somewhat of a shock to find that this much discussed phrase is there rendered " the impression of an anchor " without comment. While such a reading might be possible in the time of Hippolytus, it is a complete anachronism for Xenophanes. Anything like an iron anchor of a shape to make a recognisable impression would then have been a treasure of inestimable value : anchors in the 6th century B.C. were stones bound with an attached rope. Even a poetical philosopher would not mention the impression deep in the stone of—a stone. The assumed Greek word can only be εὐνή, originally a bed or bedding, used in the plural by Homer for anchor-stones thrown out of the prow of a ship and, according to the new Liddell and Scott " even of an iron anchor " only in a late Scholiast. One can only suppose that the translator was influenced by memory of the anchor said by Ovid to have been found far inland in the passage quoted earlier in this paper. It has seemed worth while to clear up as completely as possible the first mention of fossils in literature, especially as the true nature of these objects is taken for granted.

A further trouble is the statement by Geikie, Woodward (H. B.) and others that Aristotle mentions fossil fish. The passage alluded to is not by Aristotle and has nothing to do with fossils. " Fish are obtained at Heraclea and in Rhegium by digging in the mud in places where the water dries up. Similarly in Paphlagonia fish are obtained by digging deep in the ground, and these are of excellent quality." The last statement makes it quite certain that the reference is to fish which bury themsleves in the mud while alive. These passages occur in the " De Mirabilibus Auscultationibus," a collection of 178 short paragraphs about marvels, each introduced by some such phrase as " people tell us " ; it is usually printed with the works of Aristotle, but the greatest authority, Sir David Ross, tells me that the items vary in date from the sixth to the second century B.C. The two in question are taken from Theophrastus, fragment clxxi. He was a pupil of Aristotle's and not much later. Many editions, from the 16th to the 19th century, print beside the Greek text a Latin version in which the Greek ἰχθῦς ὀρυκτός is rendered correctly by " piscis fossilis," a fish dug up. It is to be feared that some geologists have noticed these two words, copied instead of translating " fossilis " and referred neither to the original nor to the context, even if they have not merely copied each other. Such fish are described by Polybius (xxxiv, 10) from the plains at the foot of Pyrenees : he mentions the particular grass whose roots the fish love to eat. See also Strabo iv, 1, § 6, Seneca Quest. Nat. iii, 17. A remarkable case of fish burying themselves in the hot dry summer of 1911 and reappearing with the first wet weather was described by J. Y. Buchanan. (*Nature*, 23 Nov., 1911).

Herodotus mentions shells in the mountains of Egypt (ii, 12), as did Strabo, who also gives valuable quotations from his predecessors (i, 3, § 4). " Eratosthenes points out as a most interesting subject for disquisition the fact of our finding, often quite inland, two or three thousand stadia from the sea, vast numbers of cockle-, oyster- and scallop-shells, and also salt-water lakes. He gives as an instance that about the Temple of Ammon and along the road to it for the space of three thousand stadia there are yet to be found a vast amount of oyster shells . . . Herein he agrees with the opinion of Strato the natural philosopher . . . and Xanthus of Lydia (Fifth century B.C.). Xanthus mentioned . . . that in many places he had seen a long way from the sea fossil shells, some like cockles, others resembling scallops ; also salt lakes in Armenia, Matiana and Lower Phrygia, which induced him to believe that the sea had formerly been where the land was now.” Tozer’s comment is that “ with this acute remark Xanthus laid the foundation of geology. But this science was never studied by the Greeks in the same systematic manner as geography.” Xanthus, however, is later than Xenophanes, and Tozer’s final remark is only true if emphasis is laid on the word “systematic.” Some sound geological ideas were quite generally held. Strabo also mentions nummulites : (xvii, 1) “ Among the heaps of stone chips lying at the foot of the pyramids some are found that are like lentils in form and size . . . they say that what was left of the food of the workmen has petrified, and this is not improbable.” The translation, and text, used is the latest available, in the Loeb Classical Library, but other writers end the passage “ this is not likely.” The difference in Greek is again only a single letter—οὐκ ἐπέοικε would normally mean “ is not unlikely ” ; but οὐκ ἀπέοικε can only with difficulty be made to mean “ not likely ” : it would usually be rendered “ is not seemly or proper.” I fear we must rob Strabo of the benefit of doubting the myth. He does, however, add “ indeed in my own country [Pontus] there is a hill which is full of lentil-shaped pebbles of porous stone,” which is to his credit as an observer.

Pausanias (i, 44, § 6) says that the “ Megareans alone of the Greeks possess the shelly marble (λίθος κογχίτης) ; it is very white and softer than other stone; in it throughout are sea-cockles.” Frazer quotes Fiedler to the effect that the Tertiary rocks near Megara are largely composed of bivalve shells. Plutarch says that “ Egypt was once all sea ; for which reason it is found at this day to have abundance of molluscan shells both in its mines and on its mountains ” (Isis and Osiris). Pliny (xxxvi, 10, § 11) mentions several sorts of fossils often with fantastic comments : “ The stone Lepidotes represents the scales of fishes of sundry colours, another stone appears to have fish-bones in it ; but Glossopetra (fossil sharks’ tooth) resembles a man’s tongue and grows not on the ground but in the eclipse of the moon falls from heaven : Ostracites is named from and resembles an oyster shell, but is harder.”

No doubt fossils and other stones sometimes suggested wrong ideas by false resemblances : such later writers as Aldrovandus (or Ambrosinus) and Kircher illustrate many “ figured stones.” Pliny (xxxvi, 5) says that in part of the marble quarry of Paros “ there was a vein found which, when cloven with wedges, showed naturally within the true image and perfect portraiture of a Silenus imprinted in it.” This may have been the fish-bed of Xenophanes ; is it too far-fetched to remark that published figures of *Prolebias*, the most likely representative of the sprats, show a noticeable resemblance, with their ribs, etc., to the figure of a hairy Silenus in Smith's Dictionary of Antiquities. Cicero (De Divinatione xiii) records the reported discovery of a head of Pan in the stone quarried in Chios : " I dare say there may have been a figure not wholly unlike such a head, but still certainly it was not such that you could fancy it wrought by the sculptor Scopas." Truly commendable caution.

There is no need to give every allusion to fossils ; but were there any fossil-collectors? Suetonius says that the modest palaces of Augustus (Cap. lxxii) were adorned, not so much with statues and pictures, as with . . . things which are curious either for their antiquity or rarity ; such as, at Capri, the huge limbs of sea-monsters and wild beasts, which some affect to call the bones of giants. It seems very probable that these were mammalian Pleistocene fossil bones : in the third century A.D. Clement mentions " the giants . . . men of immense bodies, whose bones, of enormous size, are still shown in some places for confirmation " (Recognitions, i, 29). A more definite passage is " quoted " from the Apology of Apuleius, the famous author of the " Golden Ass " in J. Beckmann's " History of Inventions and Discoveries " (English Translation, 1797, Vol. ii, p. 48) :—" On the Getulian Mountains he had collected petrifactions which he considered (he was defending himself on a charge of sorcery) as the effects of Deucalion's flood." This was accepted by no less an authority than Cuvier, but is a complete misreading of the text. Apuleius could not have been collecting (recent) fishes at the time named by his accusers ; he has an alibi ; he was on the Getulian Mountains ; or did Deucalion's flood take fishes there for me? In fact " this is rote sarcastikul." Appended to the moralia of Plutarch, and sometimes falsely attributed to him, is a curious treatise on " The Names of Rivers and Mountains and such Things as are therein." It is a late Alexandrian production full of magic and fantastic folklore and is again quoted under Minerals. " On a Mountain near the river Meander grows a stone that resembles a cylinder (? Crinoid stems), which when children that are obedient to their parents find, they lay it up in the Temple of the Mother of the Gods." . . . " In the river Eurotas grows a stone which is shaped like a Helmet, called Thrasydeilos, or Rash and Timorous. For if it hears a trumpet sound, it leaps towards the bank of the river, but if you do but name the Athenians it presently sinks to the bottom of the water. Of these stones there are not a few which are consecrated and laid up in the brazen Temple of Minerva." Were they fossil echinoderms? At all events fossil spines of echinoids were collected, as they were used in medicine. Dioscorides (v, 135) says they grow in Judaea, in fashion like a glans, white in colour and of very handsome form, having also lines answering one another as if made by turnery ; they were used for bladder troubles, a case of sympathetic magic. Both the use and the name " Judaean stone " survived into the eighteenth century in this country.

BUILDING AND ORNAMENTAL STONES AND MARBLES

Descriptions of the stones used by the ancients for building, etc., lists of existing monuments where they may be seen and of the localities whence they were obtained are readily accessible. Contemporary literature is meagre, except for the work of Vitrurius on architecture. Only a few directly geological points need be mentioned here.

The earliest people to use stone for such purposes in large quantity were the Egyptians, who " translated " into stone a style of architecture originally dependent on the mud bricks of the Delta when they gained control of lands further up the Nile valley and in the surrounding deserts, where a variety of good stone was available. They also developed a style of sculpture which involved an advanced technique in the cutting and polishing of hard rocks. In Egypt the climate is such that the ancient quarry faces often remain intact to the present day, preserving inscriptions carved at the time of working and revealing marks which enable the methods employed to be deciphered.

On the methods of quarrying we have learnt much from Engelbach's study of the incompletely quarried obelisk at Aswan, a block of granite 137ft. long which, if it had been successfully extracted, would have weighted about 1,168 tons (" Cleopatra's Needle " is 68½ ft. and weighs 187 tons, but two obelisks of the Roman period preserved in Rome are estimated to weigh 1,140 tons). It had been abandoned on account of the development of unexpected cracks, found when the sides were cut. A much smaller obelisk was marked out on the surface to avoid these ; the outline can be seen with suitable light, but it also had to be given up. The upper surface has been dressed flat by pounding with balls of dolerite, 5 to 12in. in diameter, average weight 12lbs. On this surface the form of the obelisk was marked out (the guide lines can still be seen) and also a trench about 3ft. wide all round, which was then sunk. There are no marks of chisels or of wedges anywhere in the trench, though both were in constant use in the same quarry. Wedging and chiselling can be seen where a corner has been cut to allow the top of the obelisk to pass when the time came to move it. Chisel-dressing is better shown on an unfinished sarcophagus nearby. The wedges were probably of metal, with thin plates now known as feathers hammered in between the wedge and the stone. Dry wooden wedges may have been used elsewhere, but here the holes have a wide splay ; when the wooden wedges were wetted in order that their expansion might split the stone, some would certainly have jumped out, and it was important with such huge blocks to avoid irregular strains. To return to the trench round the obelisk, this has been made by pounding the stone with the dolerite balls, almost certainly shod on rammers. Englebach experimented with this method, calculated the rate of progress, the maximum number of men that could be spaced to work simultaneously, and so the minimum time for cutting out an obelisk of given size. His result agrees closely with that recorded for an obelisk at Karnak, 8.8 against 8 months, the dimensions being total height 97ft., base 7.9ft. square, weight about 323 tons. Close behind the incomplete one is the place from which another has been removed. After the trench was completed it was undercut by the same method, but cracked loose just before work from the two sides met. Engelbach set an example for all archæologists in his investigations : he took with him an experienced foreman from the Italian marble quarries and consulted him on all practical points.

The Egyptians sometimes worked limestone blocks in the same way as the granite obelisk, by trenching round. They took out stone in regular lifts and made galleries in those of the best quality. Cracks were not followed, but a layer of stone was left on each side of a crack ; these now stand up as walls with fissures along them. Saws were used, copper blades fed with sand or set with emery teeth. Faced stones were dressed with marvellous accuracy ; a granite sarcophagus of 3,350 B.C. has a surface like ground glass and the parallelism of the sides is true to a 200th of an inch. For carving, tubular drills were used. Pliny mentions some fed with diamond dust. A tomb-painting at Saqqura of about 2,700 B.C. represents stone-dressing by means of stone rubbers held in the hand and used with an abrasive powder.

Dolerite, quartzite, schist and green breccia are among the other rocks used. Roof-slabs of limestone go back to at least 3,000 B.C. The famous " Imperial Porphyry " of the Dokhan range was worked in the early days of the Roman Empire ; the quarry was at the top of the hill and now shows a working face 25 metres in height ; the stone was conveyed 96 miles overland to the Nile. In the eastern desert are the great Mons Claudianus quarries in hornblende granite, which may have been started by Claudius to employ Jewish prisoners ; a pillar still on the site measures 18 by 2.6 metres.

Perhaps the greatest interest, though somewhat indirect, belongs to a quarry in mica-schist, only recently discovered ; its name is recorded in an inscription and enables it to be identified with certainty as that marked by name on a fragment of the famous Turin papyrus, dating from the reign of Seti I, 1313-1292 B.C. The largest portion has long been regarded as essentially a mining map, and it has often been reproduced. It shows the position of a gold mine, with the miners' settlement, two " roads to the sea " and other details ; one of the legends reads : " The Mountains where gold is found—they are shown by this red colour." The smaller fragments have now been fitted together by G. W. Murray. The named quarry in " Bekheny stone " (=schist),the distance thence to the gold-mine, the roads, etc., give a complete identification, with the following result. The whole area is occupied by two main rock types, mica-schist and granite ; they are shown on the map by grey and pink washes respectively ; in the former is a quarry duly marked, in the latter the quartz veins mined for gold. The main wadis crossing the area are followed by the roads and are shown on the map, the bottoms marked by a pattern of small irregularly shaped outlines; on the ground the bottoms are filled with irregular fragments of both local and non-local rocks. In short, we have preserved for us a geological map showing schist, granite and, crossing both, strips of " head " or " coombe deposits," with notes on the mines and quarries, drawn 3,250 years ago! It is noteworthy that all early demands and suggestions for geological maps have come from the economic side, which is still regarded as paramount in the construction and publication of maps by the Geological Survey of Great Britain.

Pausanias has a note on the well-known green (verde antique) porphyry (iii, 21, § 4): " Going down to the sea in the direction of Gythium we come to the Lacedaemonian village of Croceae. The stone quarry is not one continuous mass of rock, but the stones are dug out in the shape of pebbles. They are hard to work, but once worked they might grace sanctuaries of the gods, and they are specially fitted to adorn swimming baths and fountains." The rock is called Lacedaemonian Marble by Pliny (N.H. xxxvi, 55). Frazer in his commentary (iii, p. 374) describes the quarry and says " the stratum is so disrupted that it is not easy to find a lump a foot long by a few inches thick." It was very popular in Rome and was even exported to Syria. Many other types of rock are mentioned; " at Elis there is a terrace of conglomerate "—πωρίνος λίθος (Pausanias vi, 19); Aristotle's " fire-resisting "—πυρίμαχος—stone used in the furnaces for the production of Chalybean iron was probably dolomite (Mirab. xlviii); Strabo mentions most of the well-known marble quarries, but says practically nothing of the methods of working; " in Cappadocia the river Melas . . . spreads abroad in marshes and lakes and in summer time corrupts the air around the city. A valuable stone quarry is rendered almost useless by it. For there are extensive flat ledges of stone, from which the Mazaceni obtain an abundant supply of building material, but the slabs, being covered with water, are not easily detached by the workmen (xii, 2, § 8)." " Beyond Synnada in Phrygia is Docimia, a village, and the quarry of Synnadic marble. This is the name given to it by the Romans, but the people of the country call it Docimite. At first the quarry produced small masses, but now, through the extravagance of the Romans, pillars are obtained, consisting of a single block and of great size, approaching the alabastrite marble in variety of colours; although the distant carriage of such heavy loads to the sea is difficult, yet both pillars and slabs of surprising magnitude and beauty are conveyed to Rome (xii, 8, § 14)."

In Sicily the great limestone quarries of Syracuse were used by Hiero; the face is up to 90ft. in height and a mile and a quarter long; the stone was also worked by galleries. It has been estimated that over forty million cubic metres has been extracted. Some 7,000 Athenian prisoners were employed here in 413 B.C.

In the terrace-wall of the Temple of Jupiter at Baalbec, near Damascus, built by Antoninus Pius, are three blocks of limestone measuring 63 to 64 ft. in length by 13 ft. by 13 ft. These are the largest blocks known to have been used at any time in building. In the quarries is one, blocked out, but still attached at the base 68 ft. by 14 ft. and weighing about 1,500 tons. Diodorus records that Semiramis (c. 800 B.C.) caused a great stone to be cut out of the mountains of Armenia, a hundred and twenty-five feet in length and five in breadth and thickness, and brought it to Babylon (ii, 1). Much that Diodorus tells us about Semiramis is legendary, but a column inscribed with her name is in existence and the above may well be authentic.

The Romans were great masons and quarried stone of many different kinds. In the Odenwald is a well-preserved Roman granite quarry ; a pillar lying in it is 30 ft. long and tapers from 5 ft. 1 in. to 4 ft. 1 in. The laying of the stone was usually good, but in Rome blocks of travertine, an excellent building stone when laid on its bed, were sometimes set the wrong way and had speedily to be replaced or cemented over : the rostra in the Forum are an example. Vitruvius is the only author with a practical outlook and deserves quotation at some length. " I have spoken of lime and sand, both of what varieties they are and what virtues they possess. Next in order comes the description of the quarries from which both squared stone and supplies of rubble are taken and furnished for buildings. Now these are found to be of unequal and unlike virtues. For some are soft . . . others medium . . . [examples of both classes are given] . . . others hard like lava. There are also many other kinds, as red and black tufa in Campania ; in Umbria and Picenum and in Venetia, white stone which indeed is cut, like wood, with a toothed saw [see below] . . . these are all soft and only for interior use : but travertine withstands heavy loads and storms, but cracks and breaks up when fired. . . . But there are also several quarries in the neighbourhood of Tarquinii [on the coast 60 m. N. of Rome] known as the Anician, in colour like those of Alba, of which the workings are mostly round the lake of Bolsena and also in the prefecture of Statonia. These also have infinite virtues ; for they can neither be injured by weathering under frost nor by the approach of fire. But the stone is firm and wears well over a long time. . . . Now this we may especially judge from the monuments, which are about the municipality of Ferentum [near Viterbo], made from these quarries. For they have large statues strikingly made, and lesser figures and flowers and acanthus finely carved. These, old as they are, appear as fresh as if they were just made. None the less also, coppersmiths in their bronze castings get moulds from these quarries, and find great advantages from them for casting bronze. And if these were near the city it would be worth while to execute all works from these stoneyards. Since then, because of their nearness, necessity compels the use of supplies from the quarries of Grotta Rossa and Palla, and others which are nearest to the city, we must take precautions if we wish to complete our work without faults. When we have to build, let the stone be got out two years before, not in winter, but in summer, and let it lie and stay in exposed places. Those stones, however, which in the two years suffer damage by weathering, are to be thrown into the foundations. Those which are not faulty are tested by Nature, and can endure when used in building above ground. And these precautions are to be taken not only in the case of squared stones, but also for rough stone or rubble walling (ii, 7)." It may be mentioned that Roman blocks were carefully marked at the quarries with a number of the exact origin, in many cases also with a date.

In the previous chapter of his second book Vitruvius speaks of the Pozzolana found in the neighbourhood of Baiae and round Mt. Vesuvius ; mixed with lime and rubble this forms hydraulic cement. " Now this seems to happen for this reason, that under these mountainous regions there are both hot earth and many springs. And these would not be unless deep down they had huge blazing fires of sulphur, alum or pitch. Therefore the fire and vapour of flame within, flowing through the cracks makes that earth light. . . . But that there are fervent heats in these districts may be proved by this circumstance. In the hills of Baiae which belong to Cumae sites are excavated for sweating-rooms. In these hot vapour rising from deep down perforates the soil by the violence of its heat, and passing through it rises in these places."

He also hints at the idea of a geological map : " Neither the same kinds of soil nor the same rocks are found in all places and regions, but some are earthy, others of gravel, others pebbly, in other places sandy material. And generally there are found in the earth qualities of unlike and unequal kind in the various regions. But we may regard the matter especially in this way : almost everywhere, where the Apennine range encloses the regions of Italy and Etruria, sand-pits are found : whereas across the Apennines, where the land adjoins the Adriatic, none are found."

The marble quarries of Carrara were first worked about 100 B.C., and are described by Strabo (v, 2) ; eighty-ton blocks are used in Trajan's column. Everyone knows that Augustus found Rome a city of brick and left it one of marble. The Imperial city developed a passion, handed on in due course to Constantinople, for coloured marbles and ornamental stone of all kinds. In literature this is well exemplified in a comparatively short book of poems, the Silvae of Statius. In i, 2 " marble of Libya and of Phrygia was there and the hard green stone of Laconia ; there was flexuous onyx and blocks that matched the deep sea, and porphyry that excites envy in Olbanian purple and in the master dyers of Tyre." In i, 5 " Here neither Thasos nor the wavy Carystos finds place ; the onyx pines afar ; the snakestone, too, is outcast and sorrowful. Nothing is here but gleaming porphyry quarried from Numidia's tawny rocks ; nothing but the stone that, in the deep caves of Phrygian Synnas, Attis has flecked with glistening drops of his own blood, and marble of a deeper purple than fine linen dyed at Tyre." In ii, 2 a country house near Sorrento has " one hall that quite outshines the rest. Therein are marbles chosen from the heart of quarries in Greece ; some splashed with tracery as of orient Syene, some hewn by Phrygian picks up and down the lovelorn Cybele, where, as on painted stone, the white ground is picked out with rings of red. Here is marble quarried from the hills of Lycurgus at Amyclae—a mimicry of the green grass in stone. And here are bright yellow blocks from Numidia, here the marble of Thasos and of Chios and Carystian pillars that rejoice to face seawards [i.e., they feel at home again]." From other passages one can add marble from Ilium and the stone from " quarried Luna " to the list, which reads like a guide to Westminster Cathedral. A few notes may be helpful. Luna = Carrara : Numidian = giallo antico : Carystium = cipollino from Euboea, also a locality for asbestos ; it has bands of green and white : Phrygian or Sinnadic was slightly translucent with purplish, violet or crimson markings—it is mentioned by Juvenal and Tibullus and Strabo's account of the quarrying has been quoted above : Snake-stone = ophites = verde antique serpentine from Atrax on Mt. Peneius in Thessaly : onyx = onyx marble = alabastrites of Pliny = stalagmite, mostly from near Damascus or from the Egyptian Thebes : Laconia = the green porphyry mentioned above : Numidian porphyry = the red porphyry from Mons Claudianus. Many of these are mentioned elsewhere, notably in Martial vi, 42. There was also a Spanish fossil marble, red, yellow and purple from Tortosa, called " saffron-coloured " by Dioscorides and Isidorus. Somewhat similar quotations might be culled from Sidonius (died 479) or from Paulus Silentiarius, whose ode on the Church of Santa Sophia, Constantinople, was recited at its consecration on December 24th, 563.

These " marbles " were mostly sawn into thin slabs used as a veneer. Stone saws were used in Egypt and in the palace of Tiryns a saw has been found set with rectangular teeth of emery one-sixteenth of an inch long. The saw mentioned by Vitruvius cut only soft stone and may have been an ordinary metal tool. But usually the " saw " was merely a means of cutting with sand, as described by Pliny (xxxvi, 159), who notes that the coarser the sand the more labour in subsequent polishing, for which pumice is recommended. Slabs in existence show the rough groovings on the unpolished face ; no doubt they helped to bind the veneer to the underlying cement. At any rate by the end of the fourth century A.D. power-saws were in use. Ausonius in his poem on the Moselle speaks of one tributary, the Erubris, which " turns his millstones in furious revolutions and drives the shrieking saws through smooth blocks of marble, and so hears from either bank a ceaseless din." The tributary enters the Moselle just below Treves.

MINERALOGY.

On the whole Mineralogy has been better served, as regards its early history, than any other branch of geology. King's two books, on Precious Stones and Metals and on Gems and Decorative Stones, have made selections from most of the texts, mediaeval as well as classical, readily available and discuss the difficulties of interpretation and identification of species. For metallic ores, etc., the Hoover translation of Agricola's De Re Metallica is invaluable, as the copious notes give all the previous literature and history.

Theophrastus is the oldest professed mineralogist : a text, English translation and notes were published by " Sir " John Hill ; there are many inaccuracies, but a new edition with critical commentary is in preparation by the only satisfactory method, collaboration between a classical scholar and a geologist. A seventeenth century English translation of Dioscorides, including the section on minerals, has recently been published by Gunther.

As several of the names of minerals indicate, however, much of the Greek information was derived from the east. Campbell Thompson has examined a number of cuneiform texts, mostly seventh century B.C., in which words prefixed by the sign for stone are used ; they are mostly recipes for making and colouring glass and glaze. Such names as sapphire, beryl, jasper or cinnabar have a direct Babylonian ancestry ; some twenty minerals and half a dozen rocks are mentioned and there are traces of scientific tests : two white substances, chalk and gypsum, are distinguished by the addition of " acid-resisting " to the latter ; as also two blue stones, lapis lazuli and sapphire, by the qualification of " scratching," an allusion to the hardness of corundum. The Egyptians used similar materials for similar purposes, as well as a number of precious or semi-precious stones ; I know nothing of any contemporary literature.

There is, naturally, a tendency for all early mineralogy to be based on colour, and the exact meaning, if there ever was one, is often in doubt. Consequently the identification of the mineral species referred to in any particular passage is difficult or impossible. For instance, in both Greek and Latin, the word usually translated " emerald " may mean almost any green mineral, emerald or paler beryl, peridot, malachite, serpentine, green felspar (amazon stone), green quartz (prase), jasper and even green porphyry are certainly included ; Pliny mentions in all twelve kinds, in some cases with known localities. Some of the casual literary allusions may even refer to green glass. Necklaces of true emerald have been found at Herculaneum. Diodorus (xvii, 5) says that the image of Jupiter Ammon in the oasis was adorned in every part with " emeralds " and other precious stones, a statement exaggerated by other authors, who say that it was made of emerald. In the early days of the Roman Empire a brisk trade was developing in gems from Ceylon (Taprobane), India and Burmah (the Golden

Chersonese), as described, for instance, in the "Periplus of the Red Sea." With no optical instruments and hardly any chemical reagents could anyone today identify the constituents of a handful of gem-gravel from Ceylon? A possible hint that such stones were recognised as water-worn pebbles is found in an elegy on Maecenas, who died in 8 A.D. (L.C.L. "Minor Latin Poets"): "even as the beryl surpasses the common sands which the wave tosses about along with it on a distant shore."

Moreover, existing antiquities made of mineral substances have often been wrongly described by archaeologists. It is stated by Watson, quoting J. D. Middleton, "Remains of Ancient Rome," Vol. i, p. 22, that a block of fluorspar was found on the stone-masons' quay at Rome cut into slabs and used to adorn the altar in the Jesuit Church: King says (2) that he saw this material in place, that it is not fluorspar but purple and white agate, and that he was shown that it could not be scratched. Any attempt to to check the truth must be postponed, but fragments of veneer-slabs of fluorspar, well authenticated as of imperial times, found near Rome are in the Museum of Practical Geology. For Egypt we have the invaluable work of Lucas; everyone "knows" that the Egyptians used stibnite as an eye-paint; but every sample examined by Lucas proved to be galena. On the other hand, Dioscorides (v, 99) undoubtedly knew the sulphide of antimony and its uses. Some mineral names have definitely changed their meaning: Peridot from St. John's Island in the Red Sea has been identified in jewellery as far back as the Eighteenth Egyptian Dynasty; the occurrence is described by Diodorus (III, 38) and Pliny, but the name of the stone and of the island is Topaz. It was later confused with emerald from the Sikait mines in the Desert. The descriptions by Theophrastus and Pliny of sapphirus show clearly that it was, or included, lapis lazuli; but the latter referred to our sapphire as hyacinthus, which is thus described by Solinus (Polyhistor. xxxiii, Aethiopia) "of a shining blue colour, a stone of price, if it be found without blemish, for it is extremely subject to defects . . . when put into the mouth it is colder than other stones [a familiar test of a stone as against glass]. For engraving upon it is by no means adopted in as much as it defies all grinding: it is not, however, entirely invincible, since it is engraved upon and cut into shape by means of a diamond." This author is the first to mention (Cap. xxv) British jet (gagates). A fully documented dictionary of classical mineralogy is much to be desired; in its preparation the second half of the fifth book of the Herbal or Pharmacopeia of Dioscorides is likely to be more useful than the condensed catalogue of Pliny's last book, though this does give more localities: Dioscorides was an army surgeon by profession; but besides the uses of many minerals in medicine and occasionally for other purposes he gives notes on their behaviour when fired or otherwise treated, which are useful for identification. Spencer has dealt with a few of the names, and I (4) have recently discussed at length the identity of the Lapis specularis of Pliny and others as selenite. The time is ripe for a new discussion of the murrhine question, and much interest might be derived from a study of the mineral pigments of which Theophrastus, Dioscorides, Pliny and Vitruvius give detailed descriptions, perhaps combined with the accounts of paintings in Philostratus and Pausanias and the surviving paintings of Pompeii and Herculaneum. Only a few subjects can be touched on here.

Among the earliest Greek references are those on the attractive properties of amber and of what we call magnetite. Plato (Ion,533) says that the word " magnetis " was first applied to loadstone by Euripides, the usual name being " the Heraclean Stone " ; his passage on the attractive power has already been quoted. A favourite experiment was to form a chain of iron rings with no other connection. Lucretius (vi, 1046) says that " iron rings jump up and filings rave in brass bowls when the magnet-stone (*lapis magnes*) is placed beneath " ; and a few lines later that " the magnet stones (magnesia saxa) set iron in motion with their streams of influence. Incidentally, these quotations are an indication of an annoying confusion of names ; the earliest definition of " magnetite " (transliterated) is " a soft white mineral "—some magnesia compound. The experiments described by Lucretius were no doubt genuine. Statuettes of cast iron were occasionally made at quite an early period, and it is not impossible that one of these, suitably suspended, might be visibly attractedwhen a large piece of magnetite was brought near ; but there seems to be an element of exaggeration in the description by Claudian of a temple in which figures of Mars and Venus, in iron and " sculptured in magnet " respectively, rushed to embrace : a metrical translation of the whole passage is given by King (2, pp. 174, 5). Only a little more imagination, or perhaps a little deception with fine cords invisible against a suitable background in a dim religious light, is required to do without suspension and keep an iron figure poised in mid-air between pieces of magnetite in the ceiling and the floor. Such tales are frequent, and the statue grows like the traditional record catch of an angler. In Saxon England a short treatise, falsely attributed to Bede, was current, entitled " the Seven Wonders of the World " : " the fourth wonder is the iron figure of Bellerophon on horseback, which hangs suspended in the air and has neither chains nor anything else to support it ; but great magnetic stones are placed in vaults and so it is retained in assumption and remains in equilibrium. Its weight is estimated at about five thousand pounds." Although the attractive power of amber was equally familiar with that of Heracleite, no such tales arose, presumably because the substance was universally recognised as an exudation from trees, and blocks were therefore strictly limited in size. Not unnaturally the trees were thought to be extant in the distant Baltic countries. The most interesting passage is from Tacitus (Germania, xlv) :—But the Germans also search the deep and are the only people who gather amber (which they call "glesum ") in the shallows and also on the shore itself. Barbarians as they are, they have not investigated or discovered what natural cause or process produces it. Nay, it even lay amid the sea's other refuse, till our luxury gave it a name. To them it is utterly useless; they gather it in its raw state, bring it to us in shapeless lumps, and marvel at the price which they receive. It is, however, a juice from trees, as you may infer from the fact that there are often seen shining through it creeping things and winged insects, which, having become entangled in the fluid, are gradually enclosed in the substance as it hardens.

The form of crystals was to some slight extent recognised as diagnostic. Pliny (xxxvii, 2) regarded quartz or rock-crystal as a hardened form of ice or congealed water, a view still applied by workmen in our own country to crystals of selenite : it is found only on hills facing south, never north however cold : " no reason can be given why it is always hexagonal, nor how the faces come to be more polished than any artificial process could make them " : a typical Pliny mixture of fact and fancy. True diamond is indisputably mentioned by Manilius, the astronomer (iv, 926)—*sic adamas punctum lapidis, pretiosior auro*." Small points of diamond were used, mounted in iron handles for engraving gem-stones, as Pliny tells us and antique engraved sapphires prove. His " adamas " includes six kinds, of which four were probably genuine :—" The Indian appeared to have a certain affinity to crystal, being colourless and transparent, having six angles, polished faces, and terminating like a pyramid in a sharp point ; or again pointed at the opposite extremities as though two whipping-tops [these were inverted pyramids, not cones] were joined together by their broadest ends "; King's comment (1, p. 42) on this quotation is " a wonderfully compact summary this of the distinctive features of the diamond, for the six angles can only belong to an octahedron, the primary form of its crystallisation ; the two pyramids joined together by their bases expressing the case where the octahedron is perfect ; and the natural polish marking those small diamonds, perfectly crystalised, called " Naifes " by the Indians, completes the picture." Pliny calls his other kinds bastards ; we may remember our " Bristol Diamonds." Those from Cyprus were of a blueish tint, and probably analcime ; the " adamas siderites " almost certainly sapphire ; Pliny notes that it exceeds all other in weight (i.e., specific gravity : round about 4 as against 3.5 for diamond and less than 3 for analcime). There is a full and accurate account of the meaning of specific gravity in Vitruvius (ix, 9-12).

" Streak " is noticed in Aristotle's De Coloribus (iii, 793a), which, if not by him, is certainly a product of his school " some kinds of stones gives rise to different colours when rubbed like . . . . (words missing), which are black but make white marks." He ascribes the colour to pigmentation of the minute particles, which rubs off and reveals the basal colour. " When rubbed against a smooth and even surface, e.g., against a touchstone (βάσανος), they lose their blackness and get back their other colour, which comes through where the lines of the tincture in the pores are unbroken and continuous " : on the subject of dyes being taken up by materials he makes an interesting comparison—the intervals between the pores are too small to be separately seen, just as tin is invisible when blent with copper in bronze. Strabo (iii, 3 § 7) remarks that the red rock-salt of Spain turns white when pounded.

On such a purely scientific question as the origin of minerals we naturally turn to Aristotle, who hints at a theory approaching pneumatolysis. "We maintain that there are two exhalations one vaporous, the other smoky ; these correspond to two kinds of bodies that originate in the earth, fossils (τὰ ὀρυκτά = things dug up) and metallic substances. The heat of the dry exhalation is the cause of all fossils ; such are the kinds of stones that cannot be melted . . . the vapourous exhalation is the cause of all metals, those bodies which are either fusible or malleable, such as iron, copper, gold : all these originate from the imprisonment of the vapourous exhalation in the earth and especially in stones." Amongst the fossils he includes realgar and red ochre or ruddle (σανδαράκη and μίλθον). The word for realgar is used by many classical authors, both for the mineral and for the prepared pigment, and it is interesting to note that Liddell and Scott give the derivation from Assyrian, in which it may also be the yellow sulphide, orpiment. The word for ruddle has that meaning in Herodotus and Dioscorides, but in Pliny (xxxiii, 115) it may include red lead, and in later authors it becomes an alchemical or magic word for blood. In the distinction of his two main classes Aristotle was anticipated by Plato (Critias 114e) : "Atlantis yielded all the products of the miner's industry, solid and fusible alike" : the "solid products" here mean stone and marble from the quarries, the fusible metals from the mines, which were regarded, as in the Timaeus, as liquids with a high freezing point.

In the fourth and fifth centuries the surviving relics of scientific mineralogy were not only overlain with Hermeneutic fancies, but were hopelessly confused. An outstanding work is Epiphanius on Gems. He was bishop of Cyprus from 367 to 403 A.D. The nominal subject of this writing is the twelve stones of the High Priest's breastplate, including an account of the appearance and properties of the gems, magical and (supposed) medical, and of their allegorical interpretation. The complete Greek text is lost, but we have a Latin version, fragments of Coptic texts, and of Armenian and Georgian translations from a fifth century Syriac version, a sign of the popularity of the work in the near east, as also of the difficulties which beset the mere geologist. These have been assembled and edited with English translation and notes, though without, apparently, the collaboration of a mineralogist. A single passage may be quoted from the Armenian :—"The second gem is the Topazion, like to the gem carbuncle, and it too is red. It is found in Tpazey, a city of India. Its proof is thus : when you grind it on a whetstone it does not exude scarlet water or drops in accordance with its colour, but of the colour of milk, and it fills as many vessels with water as he who whets its desires. Its weight, however, does not diminish but the gem is the same as it was, neither lessened nor diminished. What comes from it, however, is useful for afflictions of the eyes and for those who suffer from thirst and those who go insane from the sea-gape, although some of the doctors give these drops to many patients." When we remember that Topaz was green peridot, or the yellow variety chrysolite, we may wonder whether the good bishop himself was in need of a dose. The passage is, however, surpassed for nonsense by Pseudo-Plutarch on rivers and mountains already mentioned : "Upon this mountain (Tmolus) grows a stone, not unlike a pumice-stone, which is very rare to be found. This stone changes its colour four times a day, and is only to be seen by virgins that are not arrived at the years of understanding. But if marriageable virgins happen to see it, they can never receive any injury from those that attempt their chastity."

THE DARK AGES AND THE RENAISSANCE.

With the decay of science among European nations that followed the sack of Alexandria in 640 A.D. we must turn to oriental languages, Arabic, Sanskrit and Pali, Persian, Tamil and so on, of which I am completely ignorant. Lyell devoted two pages to the east : I can only add a few scraps of information collected from various sources not available to him and draw attention to the gap which, as far as I am aware, exists in English scholarship. It is appropriate that this section should follow immediately on that dealing with mineralogy, as this is practically the only branch of geology with any history between the seventh and sixteenth centuries.

Finot has published texts and translations of Indian lapidaries, of which parts must be very early, since a precis dated to the sixth century exists. These describe diamond, pearl, ruby, sapphire and emerald as precious stones and fifteen, including coral and one unidentified as semi-precious. Diamond is recognised as the hardest substance known, its octahedral form is recorded much as by Pliny, who probably drew on Indian sources or described Indian stones, and its low specific gravity is noticed. Both ruby and sapphire will scratch everything except diamond, both can be recognised by their weight, their magical properties are identical, as are the localities they come from, and the two lists of colours overlap. The conclusion is almost inevitable that the jewellers knew that they were dealing with a single mineral, distinguished only as gems. Smith points out that the name corundum is derived from the Tamil Kurrandam. He also mentions three localities in southern India where beryl has been mined and where large and numerous hoards of Roman gold coins have been found ; one has been identified with a locality mentioned in Ptolemy's geography. Kunz points out that in classical writings the attractive power of loadstone is often compared to the fascination exercised by a beautiful woman : Lucian (Imag. i.) says that if such a woman looks at a man she draws him to her and leads him whither she will, just as the Heraclean Stone draws iron. Kunz refers to the French name "aimant" and continues :—"it is certainly worthy of note that in two such dissimilar languages as

Sanskrit and Chinese, the influence of this idea appears in the names given to the loadstone. In Sanskrit the word is chumbaka, or 'the kisser' and in Chinese t'su shi or 'the loving stone.' Chin T 'sang Khi, a Chinese author of the eighth century wrote that 'the loadstone attracts iron just as does a tender mother when she calls her children to her.'" A Japanese writer, Masumi Chikashige, says that a Chinese work of the second century, A.D., Pen Ts'ao deals with minerals and plants in an exhaustive fashion: it was revised and supplemented, with a slightly different title much later in the Ming dynasty. Dr. F. J. North kindly sends me the following quotation from the Chinese philosopher Chu-hsi, 1200 A.D.; it was translated for him by Dr. J. S. Lee and has not been previously published in English:—" In the high mountains I have seen shells. They are sometimes embedded in rocks. The rocks must have been earthy material in days of old, and the shells must have lived in water. The low places are now elevated high, and the soft material turned into hard stone." This puts thirteenth century Europe to shame.

Such allusions merely serve to whet our curiosity, as do those to Persian works, which are probably more important. Browne says that the Brethren of Purity was a society of encyclopaedists which flourished in Basra in the later half of the tenth century; of the fifty-one tracts the group on Natural Science includes one on Mineralogy. Only six have (when Browne wrote) been printed in any European language, namely German. The natural science was much influenced by Aristotle. Mineralogy is also treated in a book composed in the year 976 called "The Keys of the Sciences" of which an edition has been published in Leyden. There may be scraps of geology included in these works under such headings as cosmogeny. Al Masudi, who died at Cairo in 957 A.D., wrote on gold and precious stones, earthquakes and various geological problems. A French edition, "Les Prairies d'Or', 9 vols. 1861-77 exists, but I have not seen it. Al Biruni, 973-1048 A.D. is said to have given the specific gravity of eighteen precious stones and metals with great accuracy and to have explained the hydrostatic principle of artesian wells. The only translations are German: but since this paper was submitted, I learn that four extracts from Al Biruni have been published by the Archaeological Survey of India (Delhi, 1941); the title is "Biruni's Picture of the World," but the book is wholly in Arabic without even a summary in English. A reviewer in the Geographical Journal (for June 1944), says that "Biruni discourses on his theory that before the existence of mankind land had been sea and vice-versa . . . stones are discovered which, split open, show evidence of fossilized shells and what is known to the Arabs as "fishes'-ears" . . . the third extract from . . . an important treatise on precious stones, minerals and chemical substances known to the eleventh-century Orient, has already appeared in a complete edition of the work published by Professor F. Krenkow, at Hyderabad in 1938. A translation of the latter edition is a desideratum." I agree! Many fragments of oriental mineralogy, of all ages and in many languages, Chinese, Thibetan, etc., are quoted by Laufer in his studies of individual minerals, mostly published by the Chicago Field Museum, where he is curator of Anthropology; as geologists might easily miss the "Anthropological Series," those I have seen are given in the bibliography.

In the middle of the twelfth century, Mohammed Ben Mansur wrote the first mineralogical treatise in Persian—his predecessors wrote in Arabic; of him King (1) writes "He may justly claim the honour of being the first since Pliny (beyond whom he is far advanced in many points) to compose a really scientific and systematic treatise upon this branch of Mineralogy. This was his "Book of Precious Stones," dedicated to the Abasside Sultan of Persia . . . In this work he treats of each stone under three heads, viz., "Properties, Varieties, and Places producing it." The knowledge of the true characters of the different species displayed in every one of his articles is absolutely marvellous, considering the age in which he wrote. He actually anticipates by many centuries the founders in Europe of the modern science, Haüy, Möh, etc., in several of their supposed discoveries, such as defining the different species of the Corundum and Spinel, and in basing his distinctions upon the hardness and specific gravity of the several kinds." King gives a few extracts here and there on the seventy five minerals mentioned, but again what appears to be the only translation is German. Although it has been shown above that on some points Ben Mansur also had been anticipated, an English version would be most welcome.

A link with Europe is provided by the work current then under the title "the lapidary of Aristotle," which is probably ninth century Persian in origin; it is magic rather than science, as also is the so-called Orphic poem Lithica, which includes a description of a magic sphere of stone—"it is black, round and heavy, and the material is siderite"; the last word certainly refers to an iron oxide—unless it was a meteorite—and has nothing to do with the carbonate, whose name in English is chalybite. Another Mohammedan work is (Pseudo) Aristotle, De Elementis, which is of some interest as attributing the formation of mountains to plutonic causes; unfortunately it gives marine fossils as evidence that they have *subsequently* been eroded by water; it may be the work of Avicenna (Ibn-Sina, 980-1037 A.D.), who produced a reasonable classification of minerals. What passed as science in Europe at this period is well illustrated by the lapidary of Marbodus, Bishop of Rennes, dating from about 1070; it is in Latin hexameters and has mostly been translated by King: typical is the statement that if peridot was to be used as a protection against evil spirits it must be pierced, strung on the hair of an ass and attached to the left shoulder. Special interest applies to a lapidary, said to be translated into Spanish from Arabic and probably based on a Chaldean original of the eighth or ninth century, known as that of King Alfonso X, on account of the magnificent illuminated manuscript, made in 1276, and now in Madrid. It describes some 300 " stones " arranged under the signs of the Zodiac and under the planets : some are recognisable ; for instance under the first star of Aries is magnetite, under the third jet (gagates) ; but under the tenth is " the stone that recoils from milk " and under the seventeenth that which " appears in the sea when Mars is in the ascendant." The magical properties are the main theme, and one of the few real uses lies in the fact that each name is given in a variety of languages. The complete text with the charming miniatures of the finding of the stones has been reproduced in colour, with introduction from the artistic, not the mineralogical point of view, and a modern Spanish version by Montana.

Much of the Arabic learning that found its way into Europe naturally came through Spain, and in particular through Cordova. Averroes (Ibn Rushd) wrote extensive commentaries on Aristotle : he lived at Cordova (1126-1198) and his work was translated at the time into Latin. Maimonides, a Jew, whose work mainly consisted in reconciling Greek philosophy with the Bible, was also born at Cordova in 1135, but died at Cairo. This learning was passed on by Albertus Magnus, who added to it from his own observations on fossils, etc., to his pupil St. Thomas Aquinas, and so became a part of that of the schoolmen. But much Arabic learning had already reached Italy through Constantine the African, born at Carthage, who came into Italy in the middle of the eleventh century and became a monk in the monastery of Monte Cassino ; he spent his time translating Arabic medical and scientific work into Latin, and died in 1087 (Singer 1). The thirteenth and later the fifteenth centuries saw genuine revivals of old science, but little that was new. Even so it must be remembered that the Arabic texts that were translated, with all their accretions, into Latin were probably made in the first place from Syriac versions, not from the original Greek.

From the middle of the twelfth to the middle of the thirteenth century, Sicily was " a meeting place of Greek, Arabic and Latin culture, central in the history, as of the geography of the Mediterranean lands." The Emperor Roger's chief interest was in geography, but his grandson Frederick II. took an all-round interest in science and was known as Stupor Mundi—" not long before 1242 he sent out a questionnaire to be answered by Mohammedan philosophers in Egypt, Syria, Irak, Asia Minor, the Yemen and Morocco, as well as by his own " astrologer ' Michael Scot." The surviving documents have been discussed in a series of articles by Professor Haskins—" We pray you explain to us the foundations of the earth . . . . its thickness and length . . . . why the sea is salt, how sweet waters gush forth from the earth . . . . why the sea into which the rivers run does not overflow ? . . . . likewise concerning those waters which come forth warm or hot. Also we should like to know concerning . . . . the fire which bursts forth from plains as well as mountains, and what produces the smoke and . . . . what causes its blasts as is seen in parts of Sicily and Messina, as Etna, Vulcano, Lipari and Stromboli." On the cause of volcanic activity Scot's replies are based on Aristotle, but his facts indicate either personal observation or enquiry amongst those who observed. He says that the pumice ejected from the Lipari Isles is strewn far and wide over the surface of the sea and is gathered by the people for use as a building material ; it had long ago been used for the "floating bricks," described by Vitruvius. Elsewhere he mentions the magnet which attracts iron, points to the north and reconciles husbands and wives ; on the directional property he was anticipated by Jacobus de Vitry about 1218 A.D., as well as by Alexander Neckham (see below). Scot died in 1235 or 1236 : it is unfortunate that most people know him only as a magician prominent in Scott's "Lay of the Last Minstrel." Some of the writers on the Crusades have short passages of geological interest ; de Vitry's "History of Jerusalem" just mentioned also includes an attempt to explain earthquakes by the violent motion of air enclosed in hollow spaces of the earth's interior. The Sieur de Joinville, about 1248, gives an admirable description of the fossil fish of Lebanon (cap. xiv), which has often been quoted, but he makes no attempt at an explanation.

Albertus Magnus wrote his Liber Mineralium about the year 1250. On general principles (Bk. I, tract i, de lapidibus in communis) he remarks that no stone floats ; pumice only floats because it is spongy, but when powdered the actual material sinks. Fossils he attributes (tract 8, on stones having the internal and external form of animals) to a plastic force in nature (the vis formativa of Aristotle and Avicenna, the latter of whom he quotes by name) combined with an influence from the stars ; he remarks that the forms of shells are most commonly found in porous rocks, where the force is comparatively free to act. The action of petrifying springs is, however, recognised, e.g., he had seen a petrified branch of a tree on which was a bird's nest complete with the birds (picae-magpies) ; this must have fallen into the water and subsequently been turned into stone by the local peculiarity. One suspects that this specimen had been "improved" by art, just as it is or used to be possible to purchase petrified nests, mousetraps, etc., at the Knaresborough dripping well. More interesting is Book II., tract 2, of precious stones and their virtues, which describes in all 94 stones, arranged in alphabetical order of their names ; but the number includes several professed doublets and many imaginary stones of animal origin. In several instances he mentions having found the stones himself, a notable instance being Lapis specularis which he had found abundantly in various parts of France and Germany. It is clear that he is describing selenite ; it is found with gypsum, of which it is, so to speak, an extreme form (gypsi extremitus quaedam). It is easily split and is used instead of glass for making windows. When I wrote my paper (4) on selenite I had not been able to see this work ; it is satisfactory to have my identification supported by so great an authority and to add a date for the use in windows intermediate between the classical period and the sixteenth century. What is probably the result of personal experiment by Albertus is his statement that the arsenic minerals, orpiment and realgar, when heated, give off readily a white sublimate. Under the name magnes he gives a good description of magnetite and its attractive, but not its directional, property ; he includes, however, some of the mythical properties. Magnesia is a black stone much used by glassmakers ; it only melts in a fierce fire and then serves to purify the glass. Obviously this is one or more of the manganese oxides, but in classical writers the same word may be either equivalent to magnes, or soft and white—one of the magnesia minerals in modern parlance. Book IV. deals with metals, i.e. fusible ores, Book V with " minerals which seem to lie between metals and stones," e.g. salt and marchasite.

In Italy in the sixteenth century there is a succession of authors whose works, pointing to the imminent birth of Geology as a separate science, have been sufficiently described by Lyell, Geikie and others and more recently by Adams in his " Birth and Development of the Geological Sciences " which is of the greatest value if used with caution, but sadly marred by misprints and slips. Many of the new ideas may owe their inception to the genius of Leonardo da Vinci (1452-1519), whose notebooks contain as much foreshadowing of geology as of aviation and other mechanical inventions. But he published nothing, and we shall never know the extent of his influence. The Speculum Lapidum of Camillus Leonardus appeared in 1502 ; according to Joan Evans the first book is purely mineralogical ; it discusses successively the matter, cause, form, place of generation, accidents, degree of translucency, hardness and gravity of stones and gives directions for detecting counterfeit gems. He was soon followed by Frascatore (1517) who is given great credit by Lyell for ruling out the Mosaic deluge as an explanation of fossils found at Verona ; " that inundation was too transient, it consisted principally of fluviatile waters, and if it had transported shells to great distances, must have strewed them over the surface, not buried them at vast deaths in the interior of mountains (7th Ed., p. 22) ; a translation of the passage in full is given by Edwards. But in view of the quotations given above mentioning the occurrence of fossil shells deep in mines, can we doubt that the classical writers would have dealt in similar fashion with Deucalion's deluge, if religious politics had made it necessary to discuss the point. We must also thank some of the Italians for opposing the idea that fossils were of inorganic origin, formed *in situ* within the rocks as we see them by some plastic force of nature ; but no such idea can be found earlier than in Arabic writings, and, as Gordon points out, they failed to kill it : it was accepted as one explanation by Agricola and lasted well into the eighteenth century. Logan Lobley, in his book on Vesuvius quotes several contemporary descriptions of the eruption of 1538, which show that the spirit of observation was awakening, as was also the collector's instinct : in 1574 Mercati published a catalogue of the stones and minerals in the Vatican Museum; fossils are attributed to a formative influence from heavenly bodies; whether Mercati believed this, or merely found it advisable is open to doubt. Nine years earlier Gesner had produced his book "De Omne Rerum Fossilium Genere, Gemmis, Lapidibus, Metallis et Hujus-modi," which is the first text-book to include illustrations of specimens; the fossils include a fish and fishteeth, several echinoderms, Hoplites (recognisable and so named !) and another ammonite, belemnite, gastropods, lamellibranchs, etc. Many are reproduced by Adams.

In Germany the great Agricola (Georg Bauer, 1494-1554) was mainly interested in mining; the woodcuts from his De Re Metallica, mostly of mining machinery, are constantly reproduced; but his several other works (see Bibliography) contain his views on fossils, on which he accepted both the right and the wrong view, some account of cleavage in minerals and many other topics. A translation, comparable with the Hoovers' of the De Re Metallica, would be most welcome; the Geological Survey and Museum Library contains a fine copy of the several treatises bound up together. A contemporary, better known by name to the general public, Paracelsus, is also said by Pledge to have had geological notions, but I have not seen the texts.

That a real birth of Geology and the Sister Sciences took place about the year 1600 is shown by the publication in 1609 of De Boodt's well known book on mineralogy, which makes a good attempt, considering the stage reached by chemistry, at a scientific classification; while accepting a certain amount that we should call superstition (some of it still survives) he says "it is very necessary to observe that many virtues not possessed by gems are falsely ascribed to them." A more general sign of the times is the "Epitome of Science" by Daniel Sennert, an author evidently once popular, but almost entirely forgotten: he is not even mentioned in the eleventh or later editions of the Encyclopaedia Britannica. He was professor of medicine at Breslau, and his dedication is dated 1618; in the conclusion he states that he had spent twenty years in writing his book. My copy is the third Oxford edition, 1632; Adams does mention him, but his only reference gives Venice 1651 as place and date of publication. While dealing with all science in a fairly small book, he finds room to say that the crystal or adamas of Hungary and Silesia is hexagonal, the emerald of the west square, Bohemian garnet and the geodes globose and other gems other shapes. Much of the science is old, but he prunes it of all magic and astrology and is not ashamed to profess ignorance, an important step towards real knowledge —"no one can easily account for the existence of fossil plants and animals, frogs, fish, etc." "The property of the magnetic stone of pointing to the poles was not known to the ancients, though they were familiar with its attractive power; whether the cause of its directional property is to be found on earth or in the heavens is unknown to us." Evidently Gilbert's book, published in 1600, showing that the earth is itself a magnet, had not reached him.

In France there is one outstanding figure, Bernard Palissy, who was born in the diocese of Agen in 1509. He was a potter and has given his name to a type of pottery characterised by objects in high relief. Some authorities think he has received more than his due as a ceramic artist, but as a naturalist and geologist he has in my opinion had less. His pottery itself should be geologically famous, for some of it is modelled with fossil shells, mostly from the Tertiary rocks of the Paris basin ; Brogniart has recognised more than a dozen *species*. Among his writings the most important is the " Discours Admirables " on springs, metals, stones, etc., Paris, 1580. There are several editions of his Oeuvres Complètes, the best Paris 1844 ; more accessible is Morley's " Palissy the Potter," which contains translations of many passages, from which those given here are taken. Much of his importance lies in the fact that his ideas were his own, based on personal observation and practice. He had no learning and most of his work is in dialogue form " Theory " and " Practice," with the advantage always to the latter. On fossils he is particularly clear, with a discussion on how they have been transformed, by the deposition of mineral matter from percolating water, to something harder than the original. He was " puzzled for a time by those made in the fashion of a ram's horn "—ammonites—until someone in Saintes, where he then lived, brought him one which was half open and had certain dentations which fitted admirably one into the other . . . " from that time I understood that the said stone had formerly been the shell of a fish (an inclusive word, cf. our " shellfish "), which fish we see no more." He studied the distribution of strata, noting some faults ; he deduced from its fossils that the neighbourhood of Paris had formerly been a great basin of water, " a marine bed producing fishes." He says that he made drawings of all the fossil forms he saw, in order to compare and study them. He " reflected for many years " on the formation of metals and the crystalline form of many ores—tin ore is specifically mentioned. " When I had considered all such things I understood that all stones and kinds of salts, marcasites and other minerals, of which the congelation takes place in water, contain in themselves some form whether triangular, quadrangular, or pentagon, and the side which is in the earth and against the rock cannot have any form but that of the surface on which it reposes at the time of congelation." His account includes a " fifth element "—the germinative or congelative as opposed to exhalative or common water "—water of crystallisation in fact.

Palissy is strong on water-supply and the origin of springs : this part of his work, published in 1557, has been translated into English by Willett. Springs are derived from percolating rain-water, not from sea-water passing through underground channels (cf. Leonardo and Kircher), nor from condensation of air in caverns. " The cause, therefore, of water being found as much in springs as in wells is this, that beneath the earth is stone, or clay which can hold up water as well as stone, and when men seek for water in a sandy soil they would never find it if it were not that beneath the water is soil of the nature of clay, stone, slate, or mineral, which retains the water after it has passed through the lighter earth." This is entirely his own original observation. He points out that some wells in valleys draw their water from the rivers through the bordering gravels and that wells in towns are polluted by the filth that passes through the soil. In some cases " well-waters may rise above the point at which the auger meets them, provided that there is a bed of marl that has been pierced and that the water comes from a place higher than the bottom of the hole you have made." This corollary from this theory of springs is the first statement of the cause of Artesian wells : he was, of course, familiar with those of Artois.

Many other points deserve mention, if space allowed, but I must add that Palissy invited people to come and see his geological collections and gave them museum demonstrations : he also gave lectures on geology and other branches of natural history ; and the report of a geological field-meeting, on which fossils were collected, conducted by him in 1575, is perserved. Could there be a more fitting Patron Saint for the Geologists' Association—Saint in that he died a maryr to his scientific principles in the Bastille.

It remains to draw attention to a few authors, not of the greatest importance, but interesting because they belonged to our own country. The first English work to touch on geological subjects is Bede's " De Natura Rerum," about 709. Chapter xlvi is on the spherical form of the earth, xlix on earthquakes, l on the eruption of Etna. There is nothing new, but the introduction to Giles's text quotes Sharon Turner—" Bede collected and taught more natural truths, with fewer errors, than any Roman book on the same subjects had accomplished. Thus his work displays an advance, not a retrogradation of human knowledge ; and from its judicious selection and concentration of the best natural philosophy of the Roman Empire it does high credit to the Anglo-Saxon good sense." Adelard or Athelard of Bath wrote at the end of the eleventh or early in the twelfth century. According to Thomas Wright his " is the greatest name in English Science before Grosstete and Roger Bacon. He travelled widely, probably as far as Baghdad, and then taught Arabic science in France and Normandy, returning to England in " the reign of Henry Son of William." His scientific work is in seventy-six Questiones Naturales ; those of geological interest are :—no. 50 what is the cause of earthquakes, 51 why sea-water is, and 54 why river water is not salt, 55 how rivers can have a constant flow and 56 why springs are found on high ground. The fact that he discussed such questions is of more importance than the answers. Robert of Cricklade, Prior of St. Frideswides' about 1140 to 1172, visited Italy and Sicily and made a collection of extracts from Pliny ; a little later Alexander Neckham, who died in 1217, produced a work called De Naturis Rerum. He states that his object was to collect "facts" in order to draw morals from them ; some of the morals are very far-fetched. Among the geological sections is one relating to coal (ii, 50) ; under the heading De vi attractiva (ii, 88) and in a later poetical version he describes how sailors, when they cannot see the sun, touch a needle against a piece of Lodestone and float it by means of straw on a bowl of water, when it will turn itself till it points to the poles. Humboldt quotes a Provencal author of slightly later date as being the first in Christian Europe to refer to the compass needle ; apparently he did not know of the English author. A hundred and fifty years after Neckham, Sir John Mandeville, often regarded as the first English author on the subject, calls lodestone "the Shipman's stone" ; in Gesner's illustration a needle is shown suspended from the mineral.

In the middle of the thirteenth century Bishop Grosseteste and his friends pleaded the case for scientific thought and investigation, but a work of more geological interest is the De Proprietatibus Rerum of Bartholomaeus Anglicus. This made known in our country the scientific views of or attributed to Aristotle, Pliny and Isidorus with the Arabic accretions. It deals with such metals and minerals as gold, silver, mercury, electrum, iron, brass, lead, tin, the compounds of arsenic, sulphur, diamond, sapphire, crystal, etc. Of loadstone he repeats a well-known superstition, also given by Neckham "magnes is in lyke wyse as adamas ; if it be sett under the heed of a chaste wyfe, it makyth her sodenly to beclyppe her husbonde ; and if she be a spowse breker she shall move her oute of the bed sodenly by drede of fantasy." The translation is by John Trevisa as printed by Wynkyn de Worde in 1491 ; I have not seen a copy—the price nowadays would run well into four figures ; but considerable parts, with commentary, have been made available by Steele. Another early edition, published 1582, is known as "Batman on Bartholomew."

Seven of the Mediaeval English Lapidaries, dating from the eleventh to the sixteenth centuries, have been edited by Joan Evans ; the earlier are based on Isidorus and Bede with some items direct from Pliny, the later mainly on Neckham and Bartholomaeus.

Fossils (in the modern sense) do not seem to have attracted much attention, except for large Pleistocene bones, which are assumed to have belonged to giant men. It is somewhat surprising that American Palaeontology may be said to have begun in 1519 : in that year the Mexican natives showed Cortez some "giant bones," and a femur was sent by him to the king of Spain. G. G. Simpson, to whose article I am indebted for this record, remarks that both the specimen itself and the comments of the King, who asked for gold and was sent a bone, are lost to posterity.

In the middle of the fourteenth century Ranulph Higden wrote his Polychronicon, of which an English translation by Trevisa was finished on 18th April, 1387 ; another translation a century later is also printed opposite the Latin in the Rolls edition. Book I, cap. 38, includes a poem on Wales, of which the following lines are of interest :—

convalles pastum proferunt,	Valleys bryngeth forth food,
Montes metalla conferunt ;	And hilles metal right good ;
Carbo sub terra cortice,	Col groweth under lond,
Crescit viror in vertice ;	And gras above at the hond ;
Calcem per artis regulas	Their lyme is copious
Praebet ad tecta tegulas.	And sclattes also for hous.

Other items of Welsh geology from Giraldus Cambrensis (1180) and John Leland (early sixteenth century) are given by North in the paper quoted below. In 1600 appeared Gilbert's De Magnete, which treats of the directional as well as other properties ; the book is described by Singer as the first important work on experimental science to be printed in England ; the new spirit had appeared. It may be well to remark that a work to be seen in most libraries, itself far outside our period, Webster's Metallographia of 1671, gives a long list of earlier writers, Baccius, Cardanus, Caesalpinus and many others. Webster says they copy each other and add little to Aristotle and his school ; however, when he comes to detailed descriptions he quotes freely from them and may, therefore, serve as a useful guide, while the originals are almost inaccessible.

One author just within our limit is of real importance as an early geologist, the Welshman Robert Owen. He wrote "On the course of the strata of coal and lime in Pembrokeshire," followed by "The Description of Penbrookshire in generall," completed in 1603. It was published with notes by his great grandson, Richard Fenton, in the Cambrian Register for 1796. Buckland and Conybeare devote a quarto page to him, with the remark "This essay of Owen is a work of the highest interest, as being the earliest example extant in any language of what can properly be called Geological investigation." This may be somewhat of an exaggeration, but Owen produced in words what almost amounts to a geological map of South Wales. His object in tracing "the run of veins of limestone" was that "it may be a guide to some parties to seek the lymestone, whereas yett it lyeth hidd, and may save labour to others in seeking it, where there is noe possibility to finde it." His work has been summarized by North in a paper with less wide circulation than it deserves, and with his permission I quote it. "Finding that the distribution of certain beds of limestone was "not soe well noted, as fitt to be known," Owen traced in surprising detail, considering the difficulties of travel at the time, the distribution of the Carboniferous Limestone in South Wales. There are, as one would expect, inaccuracies in his descriptions of the outcrops, but he was aware that a 'vayne' of limestone runs across Pembrokeshire from west to east until it is lost beneath the sea beyond Pendine, and then passing under Laugharne marshe, appeareth againe . . . and entereth in between the two ryvers of Gwendraeth' ; he then proceeded to trace it to 'llanebea' and 'Mynith Crybarth,' and across the Neath Valley towards Abergavenny. There was, he further stated, a second 'vayne' that, passing out of Pembrokeshire and ‘ going for twenty myles from Tenby all under the salt water ’ reappears in Gower, and extends to the ‘ Mombles,’ beyond which it ‘ goeth againe under the salt water and continueinge right east is founde againe at the sea side over the water in Glamorgan at Kyffing water [i.e., Kenfig] a little above Margam, and heldinge a course right east from thence, passeth all the sweete and fruitfull vale of Glamorgan all along under the mountaynes ’ ; eventually crossing the River Rumney ‘ it is founde at or neare Tombarton Hill [Twyn-barllwm, near Risca] and from thence passeth towards Chipstowe towne.’

If Owen’s description of the two “veins ” of limestone is compared with the outcrop of the Carboniferous Limestone along the southern or northern edges of the Coalfield, the extent of his knowledge cannot but excite one’s admiration. North makes the position very clear by figuring a geological map with the relevant extracts from Owen shown in labels with pointers.

Owen also dealt with the coal, though in less detail ; he has some very good observations on the drift, with “ stones that have been worn by the sea or some swift river ” and in the clay cockle and “ muskell ” shells and such like ; he attributes their presence to the flood.

By the opening of the seventeenth century in England and Wales, France, Germany and Italy the infant science of Geology had come to birth.

BIBLIOGRAPHY.

1. CONTEMPORARY AUTHORS.

Texts and translations are listed ; wherever available, the Loeb Classical Library (L.C.L.), in which text and translation face each other on opposite pages, is referred to. All translations used have been compared with the original, unless otherwise stated, emendations being made as necessary. Roman figures give the century B.C. or A.D.

Adelard of Bath 1st half xii A.D.
Questions Naturales : no text seen ; trans. see Gollancz.

Agricola, G (=Georg Bauer)
De Re Metallica : 1st Latin ed. 1556. Trans. H. C. & L. H. Hoover, London 1912.
De Ortu et Causis Subterraneorum :
De Natura eorum quae effluunt ex terra :
De Natura Fossilium : De Veteribus et Novis Metallis : Bermannus. Basle, 1546.

Albertus Magnus, Bp. of Ratisbon c. 1250 A.D.
De Mineralibus et Rebus Mettallicis Librae Quinque.
Text in Opera Omnia, ed. A. Borgout, vol. v, Paris, 1890.

Anon. Aetna. i A.D.
Text & trans. *in* ‘ Minor Latin Poets,’ L.C.L. 1935.

———. Early Indian Lapidaries. vi-xii A.D.
Texts (mostly Pali), Trans. (French) and notes, L. Finot. Paris, 1896.

———. Periplus of the Erythraean Sea. i A.D.
Text (Greek) and Latin version *in* ‘ Minor Greek Geographers,’ Oxford, 1698.
Trans. & notes W. H. Schoff. New York, 1912.

APULEIUS. Apologia. ii A.D.
Text : Casaubon, 1594.
Trans. : H. E. Butler, Oxford, 1909.

ARISTOTLE. iv. B.C.
Text : Bekker, Berlin, 1831-1870.
Trans. : Oxford, v.a. and v.d., especially Meteorologica, E. W. Webster, 1923., and De Mirabilibus Auscultationibus (Pseudo-A), L. D. Dowdall, 1909.

AUGUSTINE, BP. OF HIPPO. City of God. d. 430 A.D.
Text : ed. J. E. C. Welldon, London, 1924.
Trans. : M. Dods, Edinburgh, 1871, and many others.

AULUS GELLIUS. Noctes Atticae. ii A.D.
Text & trans. : L.C.L.

AUSONIUS. The Moselle. iv A.D.
Text & trans. : L.C.L., 1919.

BEDE. De Natura Rerum. 672-735 A.D.
Text in Complete Works, ed. J. A. Giles, vol. vi, London, 1843.

——— (Pseudo). De Septem Mundi Miraculis, *ibid.*, vol. iv.

DE BOODT, A. Gemmarum et Lapidum Historia, 1st ed. Leyden, 1609 ; 3rd ed, with additions by de Laet and text of Theophrastus on Stones, Leyden, 1647.
French trans. of 1st ed. ‘Le Parfaict Joaillier,’ Lyon, 1644.

CICERO. De Divinatione. i B.C.
Trans : Bohn, ‘Nature of Gods, etc.’

CLEMENT. Recognitions. 1st half iii A.D.
Text : Migne, Pat. Lat.
Trans. : T. Smith, Ante-Nicene Christ. Lib. III. Edinburgh, 1867

COSMAS INDICOPLEUSTES. Christian Topography. Written 534-537 A.D.
Trans., with reproductions of original drawings, J. W. McCrindle, London (Hakluyt Soc. No. 98). 1897.
Text not seen.

DIO CASSIUS. Roman History. ii/iii A.D.
Text and trans. : L.C.L. 9 vols. v.d.

DIODORUS SICULUS ii B.C.
Text and Latin version : Hanover, 1604.
Text : Tauchnitz, 6 vols. Leipzig, n.d.
Trans. : G. Booth, London, 1700.
Text & trans. : L.C.L. 2 vols. out of 10.

DIOSCORIDES. i A.D.
Text & Latin version. Frankfort, 1598.
Trans. : J. Goodyer (1655), edited R. Gunther. Oxford, 1934.

EPIPHANIUS, BP. IN CYPRUS. 493 A.D.
Text & trans. : R. P. Blake and H. de Vis (Studies and Documents vol. 2). London, 1934.

GESNER, C. De rerum fossilium, lapidum et gemmarum . . figuris. Zurich, 1565.

HERODOTUS. v B.C.
Text & trans. : L.C.L. 4 vols.
Trans. : H. Carey, London, 1847.

HIGDEN, R. Polychronicon. mid. xiv A.D.
ed. C. Babington, Rolls Series, vol. i, 1865.

HIPPOLYTUS. Philosophumena. iii A.D.
Trans. : F. Legge, 2 vols. London, 1921.
For text see under Origen.

ISIDORUS, BP. IN SPAIN. Etymologiarum. vi/vii A.D.
Text : Oxford, 1911, 2 vols. (Lib. xvi De Lapidibus et Metallis in vol. 2.)
No trans.

JOINVILLE, LE SIEUR DE 1248 A.D.
Trans. : J. Hutton, 4th ed. London, 1875 (Fossil Fish, p. 178).
Also in Everyman's Lib.
Text not seen.

LUCIAN. Imagines. ii A.D.
Text & Latin version in Opera Omnia, vol. 2, Amsterdam, 1687.

LUCRETIUS. i B.C.
Text : trans. and notes : H. A. J. Munro, 4th ed. Cambridge, 1886.
Trans. : Everyman's Lib., etc.

MELA. De situ orbis. i A.D.
Text used, Exeter, 1711 (see under Solinus).
No trans.

NECKHAM. De Naturis Rerum. 1157-1217 A.D.
Text : ed. T. Wright, Rolls Series. London, 1863.
No trans.

ORIGEN. Philosophumena. iii A.D.
Text & Latin version : ed. Gronovius, Hamburg, 1706.
Text in Migne, Pat. Gr., vol. xvi, pt. 3. 1863
This work now attributed to Hippolytus, q.v.

OROSIUS. History of the World (to 416 A.D.). v A.D.
Text (Anglo-Saxon) and trans. : J. Bosworth. London, 1859.

OVID. Metamorphoses and Fasti. i B.C. ; iA. D.
Texts & trans : L.C.L.

OWEN, G. History of Pembrokeshire. late xvi A.D.
Published by R. Fenton, Cambrian Register. 1796. and ed. H. Owen, Cymmrodorian Record Series, 1892.

PALISSY, B. Discours Admirables. Paris, 1580.
Œuvres complètes ed. A. France. Paris, 1880.
Trans (part only) : " Resources—A Treatise on Water and Springs," by E. E. Willett, Brighton, 1876.

PAUSANIAS. ii A.D.
Text : Tauchnitz, Leipzig, 3 vols. 1829.
Trans. & commentary : J. G. Frazer.
Text, trans. and companion volume : L.C.L.

PHILOSTRATUS. Imagines. ii/iii A.D.
Text & trans. : L.C.L.

PINDAR. v. B.C.
Text & trans. : L.C.L.

PLATO. v/iv B.C.
Text & trans. : L.C.L.
Text & notes. : Timaeus and Critias, A. E. Taylor. London, 1929.

PLINY (the Elder). Natural History. d. 74 A.D.
Text : ed. Gronovius. Leyden, 1669.
Trans. : Philemon Holland. London, 1634-5.
,, Bostock and Riley. Bohn, London, 1855.
Text & trans : L.C.L. 3 vols. only of 10 ; these do not include the books dealing specifically with minerals : see also Bailey in Part II.

PLINY (the Younger). Letters. c. 100 A.D.
Text & trans. : L.C.L.

PLUTARCH. Lives. 1 A.D.
Text & trans. : L.C.L. 11 vols.
Trans. : Everyman's Lib. (3 vols.), etc.

———. Morals. i A.D.
Text & trans. : L.C.L. 7 vols. only, of 14.
Text : Tauchnitz, Leipzig, 6 vols. 1866-68.
Trans. : Complete (with Pseudo-P.) " By Several Hands." London, 3rd ed., 1694.
" On the Face in the Moon," trans. & notes A. O. Prickard, Winchester and London, 1911.

POLYBIUS. ii B.C.
Text & Latin version,: Casaubon. Paris, 1609.

PROCOPIUS. History of the Wars. vi A.D.
Text & trans. : L.C.L. 7 vols.

SCOT, MICHAEL. Mensa Philosophica. d. 1235 or 36.
Text : Frankfort, 1602 (not seen).
see Haskins, pt. II.

SENECA. Naturales Questiones. i A.D.
Text : Tauchnitz, Op. Om. tom. v. Leipzig, 1869.
Trans. & notes : " Physical Science in time of Nero," J. Clarke & A. Geikie, London, 1910.
Epistolae morales.
Text & trans. : L.C.L. 3 vols.

SENNERT, D. Epitome Naturalis Scientiae, 3rd ed. Oxford, 1632.

SERVASIUS. Text & trans. : *in* Minor Latin Poets, L.C.L. iv A.D.

SILIUS ITALICUS i A.D.
Text & trans. : L.C.L.

SOLINUS. Polyhistoria. ii A.D.
Text *in* Antiquitatum Variarum Auctores (which also includes Mela). Lyons, 1560.

STATIUS i A.D.
Text : ed. J. S. Philimore Oxford N.D.
Trans. : D. A. Slater. Oxford, 1908.
Text and trans. : L.C.L.

STRABO. Geography. i B.C./i A.D.
Text & trans. : L.C.L. 8 vols.
Also trans. : Bohn Lib. 3 vols. 1912.

SUETONIUS. ii A.D.
Text & trans. : L.C.L.
Trans. : Bohn Lib. 1893.

TACITUS. Histories & Annals. i/ii A.D.
Text and trans. : L.C.L. 4 vols.
Dialogues Agricola & Germania.
Text and trans. : L.C.L.
Trans. in A. J. Church & W. J. Brodribb, " Minor Works of T.," London, 1893.

THEOPHRASTUS. ii B.C.
Complete text : ed. Heinsius, Leyden, 1613 ; text & Latin version : (Didot). Paris, 1931.
" On Stones." Text, trans. (both inaccurate) and notes : " Sir " J. Hill, London, 2nd ed., 1774.

THUCYDIDES. v B.C.
Text and trans. : L.C.L. 4 vols.
Trans. : World's Classics, 1943.

VITRUVIUS. De Achitectura. i B.C.
Text & trans. : L.C.L. 2 vols.

Vitry, Jacobus de. History of Jerusalem. c. 1218 A.D.
Text not seen.
Trans. : A. Stewart, "Palestine Pilgrims' Text Soc." 1896. [This is not complete : one of the chapters omitted contains an important passage on the magnet.]

Webster, John. Metallographia. London, 1671.

Xenophanes. vi/v B.C.
Quoted by Origen or Hippolytus, q.v.

II. MODERN AUTHORS.

Adams, F. D. Birth and Development of Geological Sciences. London, 1938.

Bailey, K. C. Elder Pliny's Chapters on Chemical Subjects, 2 vols. London, 1929, 1932.
These give revised text, trans. & notes ; they include some minerals.

Beckmann, J. History of Inventions and Discoveries. Trans. from German by W. Johnston. 1st ed. 3 vols., London, 1797. 2nd ed. 1814 has a 4th supplementary vol., which includes articles on Tin, Manganese, etc.

Bromehead, C. E. N.
(1) The Evidence for Ancient Mining, *Geog. Journ.*, August, 1940.
(2) The Early History of Water Supply, *ibid.* March and April, 1942.
(3) Ancient Mining Processes. *Antiquity*, September, 1942.
(4) The Forgotten Uses of Selenite, *Min. Mag.*, September, 1943.

Buckland, W., and W. D. Conybeare. Observations on the S.W. Coal District of England, Appendix I—Some early geologists who have noticed the S.W. Coal District. *Trans. Geol. Soc.*, 2nd ser., vol. I, 1824.

Della-Torre, Dom J. M. Histoire du Vésuve, French trans. from Italian, Paris, 1760. Includes texts of Latin authors and Latin versions of Greek ; also contemporary account.

Eastman, O. R. Variae auctoritates, *Science*, N.S., vol. xx, 1904, pp. 215-217. Deals with misquotations and mis-attributions of Xenophanes on fossils.

(Edwards, W. N.). Guide to . . . Early History of Palæontology, *Brit. Mus.* (*Nat. Hist.*), 1931.

Engelbach, R. Problem of the Obelisks, London, 1923.

Evans, Joan. Magical Jewels of Middle Ages, Oxford, 1922.

——— and M. S. Serjeantson. English Mediæval Lapidaries, *E. E. Text Soc.* 190, London, 1933.

Finot, L. See Anon. Early Indian Lapidaries in Part I.

Fletcher, L. Guide to the . . . minerals mentioned in the Bible, *Brit. Mus.* (*Nat. Hist.*), 1911.

Geikie, A. Founders of Geology, 2nd ed., London, 1905.

Gollancz, H. Dodi Ve-Nechdi . . . to which is added the first English translation of Adelard of Bath's Quaestiones Naturales, London, 1920.

Gordon, W. T. Plant Life and the Philosophy of Geology (Pres. Address Sec. C), *Brit. Assoc. Rep.* (Aberdeen), 1934.

Grant, A. Aristotle (Ancient Classics for English Readers), Edinburgh and London, 1910.

Haskins, C.H.
(1) Michael Scot and Frederick II, *Isis*, vol. iv., 1921, pp. 250-275. (This includes Latin text of Scot's replies to the questionnaire.)
(2) Science at the Court of the Emperor Frederick II, *Amer. Hist. Rev.*, vol. xxvii, 1922, pp. 669-694 (a more general account).

Humbodlt, A. von. Cosmos. English trans. Bohn Lib., London, 1849.

Hume, W. F. Geology of Egypt, vol. II, pt. 3, 1937.

Johnston-Lavis, H. J. South Italian Volcanoes, Naples, 1891 (gives classical refs. for Aetna, but not for Vesuvius : many misprints).

King, C. W. (i) Precious Stones and Metals, London, 1867.
(2) Gems and Decorative Stones, London, 1867.

Kunz, J. F. Curious Lore of Precious Stones, Philadelphia and London, 1913.

Laufer, G. (1) Die Sage von den Goldgrabenden Ameison, *T'oung-Pao*, Serie II, vol. ix, 1908.
(2) Notes on Turquoise in the East, *Chicago Field Mus.*, Anthropological Series, vol. xiii, no. 1, 1913.
(3) The Diamond—A Study in Chinese and Hellenistic Folk-lore, *ibid.*, vol. xv, no. 1, 1915.

Logan-Lobley, J. Mount Vesuvius, London, 1889.

Lones, T. E. Aristotle's Researches in Natural Science, London, 1912.

Lucas, J. Ancient Egyptian Materials, 2nd ed., 1934.

Lyell, C. Principles of Geology, 7th ed., London, 1847.

Masumi Chikzshige. Oriental Alchemy, Tokyo, 1936.

Montaña, G. F. Lapidario del Rey D. Alfonso X, Madrid, 1881. (Coloured Lithog. reproduction of illuminated MS. and transliteration).

Morley, H. Palissy the Potter. London, 2nd ed., 1855.

Murray, G. W. Gold Mine of the Turin Papyrus, Appendix I in J. Ball, Egypt in Classical Geographers, Cairo, 1942.

North, F. J. (1) From Giraldus Cambrensis to the Geological Map, *Rep. & Trans. Cardiff Nat. Soc.*, vol. lxiv, 1931.
(2) Paviland Cave, . . . the Deluge. . . *Annal. Sci.*, vol. v, 1942.

Pledge, H. T. Science Since 1500, *Sci. Mus.*, London, 1939.

Pullen, H. W. Handbook of Ancient Roman Marbles, London, 1894.

Sarton, G. H. L. Introduction to History of Science, 2 vols., Baltimore, 1927 and 1931.

Simpson, G. G. Discovery of Fossil Vertebrates in N. America. *Journ. Paleon.*, vol. xvii, 1943, pp. 26-38.

Singer, C. (1) From Magic to Science, London, 1928.
(2) *in* Science, Religion and Reality, London, 1925.
(3) Short History of Science, Oxford, 1941.

Smith, V. A. Early Histroy of India, 3rd ed., Oxford, 1914.

Spencer, L. J. Some Mineral Names, *Amer. Min.*, May. 1937.

Steele, R. Mediæval Lore from Bartholomew Anglicus, London (King's Classics), 1905.

Taylor, E. G. R. Ideas on the Shape, Size and Movements of the Earth. *Hist. Assoc. Pamph.*, 126, London, 1943.

Thompson, R. Campbell. Chemistry of Ancient Assyrians, London, 1925.

Tozer, H. F. History of Ancient Geography, 2nd ed., Cambridge, 1935.

Watson, J. Marbles, London, 1916.

Woodward, H. B. History of Geology, London, 1911.

Zittel, K. A. von. History of Geology and Palæontology, trans. M M. Ogilvie-Gordon, London, 1901.

A SECTION IN THE LOWER LONDON TERTIARIES IN BALLARDS WAY, CROYDON, SURREY.

(Weald Research Committee Report, No. 33).

By F. GOSSLING, B.Sc., F.G.S.

[*Received* 30*th June*, 1944.]

THE section to which this communication relates was described before the Association on 18th May, 1928. It was exposed in the face of the escarpment of the Lower London Tertiaries, and is situated along the eastern end of the old bridleway which leads from Croham Road, South Croydon, to join Coombe Road on the top of the Addington Hills. In connection with the building of the new village at Selsdon, Croham Road, South Croydon was extended and a branch from this extension runs up eastward and joins the bridleway just east of Ballards Farm. From its junction with the bridleway, the new road, now named Ballards Way, runs level for a few hundred feet, and then rises from about 350 feet to 475 feet above O.D. in about 1,500 feet, and it was in this stretch that the main section was exposed. The section was displayed in part by the cutting back of the N.W. bank of the old bridleway, and in part by the excavation of a deep sewer trench. The bank section consists, first, of a low cliff about 200 feet long with a maximum height of 6 feet, beginning about 450 feet from the foot of the rise. Then, after a gap of about 100 feet, the bank section is continued, rising gradually from road level to a maximum height of about 12 feet in the course of about 500 feet, and then running nearly level until the road rises to the same height in about another 200 feet.

The trench exposed a much clearer view of the rocks than the bank, but the section drawn embodies the information yielded by both. From the farm to the entrance to the grounds at Ballards House (now the school of the Drapers' and Warehousemen's Company) the trench was cut in 'run of the hill' and Chalk of the *Marsupites* zone, passing near to G. W. Young's Chalk pit No. 13 [1*]. This part of the trench was unfortunately filled in before I saw it, but it was reported to be in superficial material. Actually, there can be little doubt that it ran over, if not in part, in Thanet Sand. The first low cliff follows, and this shows first a dull, buff silt, glauconitic and micaceous, the lower end of which is strongly suggestive of Thanet Sand. It passes upwards into a glauconitic, greenish, silty, very fine sand, which is succeeded by a bright red and grey mottled uniform clay, the top of which is not visible. Beyond this point the cliff falls for about 100 feet, and the trench was filled in. The foreman reported that it ran through a dark clay suitable for brick-making. Specimens of the material thrown out indicated reddish and dull buff coarse and fine silts, with sometimes about 20 per cent. of fine sand. Over this came a remarkable gravel composed of small, quite black, round pebbles, with little sand, which the foreman called "pea-beach." No reliable estimate of its thickness was obtained, but probably it was only a few feet thick, judging from the quantity thrown out. Above the "pea-beach" comes a thick bed of red buff and dull buff silts, in part laminated, which are followed by a clean, very fine, yellow sand and coarse silt. This passes up into Blackheath gravel with sand. There follows a band, 2 feet thick, of stiff grey clay, which first dips steeply N.E. and then becomes nearly horizontal, and formed the bottom of the trench for some distance. Over this comes more gravel in a grey clay matrix; and, finally, typical Blackheath Gravel. The latter, with more or less sand, sometimes silty, forms the flat ground through which the last 600 feet of the road passes.

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* For List of References see p. 138.

It is difficult to estimate the individual thicknesses of these beds, but it is clear that from the top of the Thanet Sand to the typical Blackheath Gravel the road rises at least 65 feet. Moreover, the dip at the top is 5 degrees in the direction of the road, and at the lower end the mottled clay and green sand appear to dip at about 8-10 degrees. In this latter part, however, there may have been some slipping in the face of the escarpment, and the 5 degree dip at the upper end obviously does not continue, but flattens out to the regional dip of about 2 degrees or less.

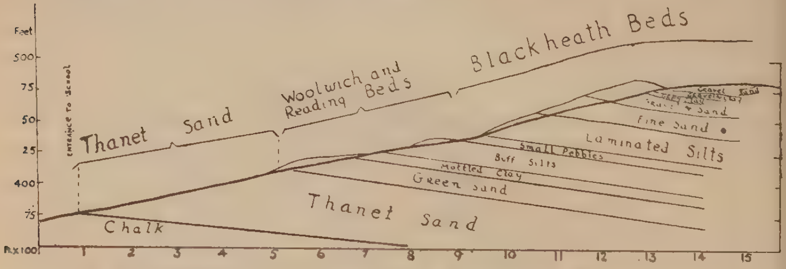

FIG. 6.—SECTION IN BALLARDS WAY, ADDINGTON HILLS, SURREY.
[Vertical Scale 2.7 times the Horizontal.]

Assuming that the regional dip of 2 degrees holds, a section drawn to scale gives the following thicknesses, viz.:

	ft.	ins.
Typical Blackheath Gravel and sand, upwards of	8	0
Grey clay (2ft.) and clayey gravel	5	0
Clean yellow, fine sand and coarse silt, with seams of gravel near the top ... ... about	25	0
Buff and white laminated silt, the upper part coarser than the lower ... ... about	25	0
Small round black pebbles ("pea-beach")	2 0—3	0
Red buff and dull buff, fine and coarse silts, sometimes with 20% of fine sand ... ... about	18	0
Mottled red and grey clay ... ... more than	4	0
Green, glauconitic, silty fine sand	6	0
Dull, buff silt, glauconitic and micaceous ... ... about	15	0
Thanet Sand ... ... about	40	0
Chalk		

In this description the terms "coarse" and "fine silt" are used in the sense defined by Prof. P. G. H. Boswell, viz., coarse silt from 0.10 to 0.05 mm. and fine silt from 0.05 to 0.01 mm.

We have, therefore, over 100 feet of strata—sands, silts and clays—between the Thanet Sand the typical Blackheath Gravel. The gravel and fine clean sand below it can safely be regarded as of the Blackheath series, but the silty beds and clays below require more consideration. Unfortunately, no fossils have been found in these exposures, and this renders correlation with other sections in the neighbourhood more difficult. There is no other record of a detailed section in the Lower London Tertiaries nearer than that in the railway-cutting described by Klaassen [2]. Klaassen did not allot the beds there, above the Thanet sand, to any definite horizon, although he evidently regarded most of them as belonging to the Woolwich and Reading Beds. Whitaker [3], however, later reproduced Klaassen's section, dividing it into Woolwich and Reading, and Oldhaven and Blackheath beds. The section may be summarised as follows :—

OLDHAVEN AND BLACKHEATH BEDS.

		ft.	ins.
Brown and grey laminated clayey sand	up to	**10**	**0**
Loose grey sand with partings and thin bands of clay ...	up to	24	0
Pebble beds ; consisting of sands with pebbles over massive pebble beds	up to	15	0

WOOLWICH AND READING BEDS.

	ft. ins.
Hard shell beds and clayey shell beds	12 0—20 0
Mottled clays	4 0—21 0
Black pebble bed	1 6
Bottom bed ; green sand 3.0 ; and greenish brown sand, grey sand and brown clayey sand 10.6	13 6
	80 0—105 0

That is how Whitaker classed 49 feet of clayey sands with a pebbly base as part of the Blackheath Beds and a maximum of 56 feet as Woolwich and Reading Beds.

When Whitaker first surveyed this district he wrote as follows : "East of Ballards there is again a very narrow outcrop of the formation (Woolwich and Reading Beds) now described, and plastic clay occurs in a pond on the westerly slope of the spur" [4]. This is probably the pond which now exists about half-a-mile S.E. of the Ballards Way section at about 440-450 feet above O.D. Also he gives [5] the section in the railway-cutting at South Croydon (modified after Prestwich) as containing :—

		ft.	ins.
Oldhaven Beds : Pebbles	say	9	0
Woolwich and Reading Beds :			
Clay shell bed	about	6	0
Mottled clay	about	25	0
Bottom bed : Green sand with pebbles		5	0

At Addington [**6**] he gives a similar section for the Woolwich and Reading Beds, viz. :

Clay and shelly clay.
Plastic clay.
Clayey green sand.

The presence of 20 feet or more of sands underlying the Blackheath pebbles at Croham Hurst, as well as a fossiliferous pebble bed overlain with grey sand and layers of pipe clay at Park Hill, Croyodn, was described by H. B. Woodward [7]. He also mentioned (*ibid*) that H. M. Klaassen noted the occurrence of a grey sand with impure pipe clay, and also silver sand, at the base of the pebble beds (Blackheath) near the Sandrock Hotel, Addington Hills, the lower fossiliferous pebble bed being absent. This last exposure is rather more than half-a-mile N.N.E. of the Ballards Way section ; Klaassen's description of it corresponds very closely with the upper portion of the section in Ballards Way.

In view of these records, on the one hand, of green sand and mottled clay at the base of the Woolwich and Reading Beds, and, on the other hand, of silver sand and clayey sand below the typical Blackheath pebbles, and notwithstanding the apparent absence of shell beds, it seems quite reasonable, tentatively at any rate, to divide the hundred feet or so of sands and silts, which separate the Thanet Sand from the typical Blackheath Gravel in Ballards Way, into two portions, allotting the green sand, mottled clay and reddish and dull buff silts to the Woolwich and Reading Beds, and the "pea-beach" pebble bed and the overlying laminated silts and clean silty sand to the Blackheath series. Such a division gives 43 feet to the Woolwich and Reading Beds, and upwards of 58 feet to the Blackheath Beds below the typical gravel.

In the recent Memoir of the Geological Survey of South London [**8**], Dewey in describing the local Woolwich and Reading Beds, says : "The northern slope of the Addington Hills is covered with woods in which grow some fine forest oaks, but sections of the clay are rarely seen. The clay is still more difficult to trace on the southern slope of these hills, owing to the masses of pebbles washed down from the overlying Blackheath Beds ; here and there, however, the clay was found, and a generalised line could be drawn on the map to indicate its position." The line so drawn runs across the Ballards Way section approximately where the division of the Woolwich and Reading beds and Blackheath Beds above suggested would bring it.

REFERENCES.

1. Young, G. W. 1905. The Chalk Area of North East Surrey. *Proc Geol. Assoc.*, vol. xix, p. 201.
2. Klaassen, H. M. 1883. On a Section in the Lower London Tertiaries at Park Hill, Croydon. *Proc. Geol. Assoc.*, vol. viii, pp. 226-248.

3. Whitaker, W. 1889. The Geology of London, vol. I. *Mem. Geol. Surv.*, pp. 130-132.
4. ———. 1872. The Geology of the London Basin, vol. iv, Part 1, *Mem. Geol. Surv.*, pp. 110.
5. ———. *ibid.*, p. 109.
6. ———. *ibid.*, p. 110.
7. Woodward, H. B. 1909. The Geology of the London District. *Mem. Geol. Surv.*, p. 30.
8. Dewey, H., and Bromehead, C. E. N. 1921. The Geology of South London. *Mem. Geol. Surv.*, p. 25.

FIELD MEETING AT CROYDON, SURREY.

Saturday, 20th May, 1944.

Report by F. Gossling, B.Sc., and A. J. Bull, Ph.D., F.G.S.

MEMBERS and friends to the number of 29 assembled at East Croydon Station. It was noted that the ancient Fairfield to the south of George Street consisted of the flat top of the aggradation gravel of the Boyn Hill Terrace ; much of the gravel here has been removed in cuttings for railways, but exposures of about 15 feet could be seen.

The party walked through Park Hill Recreation Ground, where Thanet Sand has been seen, and down the steep escarpment of the garden of Coombe Cliff. The escarpment consists of Woolwich and Reading Beds on Thanet Sand, which rests unconformably on Chalk of the *Uintacrinus* band, but no exposures were seen.

The course was then taken up Coombe Road eastwards, and although the ground rises steadily, the same zone of the Chalk is exposed at the surface. There is here a change in the direction of the dip of the Chalk, which instead of being northward towards the middle of the London Basin acquires a westerly component that makes the base of the Thanet Sand resting on the Chalk fall about 180 feet in altitude from Addington Hills to Coombe Cliff.

On the way up to Addington Hills[1] it was noted that the Tertiary escarpment recedes northward, but it returns to merge with the main escarpment at Addington and the Ballards. At the railway bridge a little Chalk exposed in the road is frost-shattered and shows a solution-eroded surface with a little drift on it.

Where Conduit Lane and Oaks Road cross Coombe Road, it was pointed out that the party had passed on to Thanet Sand, and that the clays of the variable Woolwich and Reading Beds throw out springs in places. Conduit Lane is usually wet at one point, at the road junction is a pond now hidden behind bushes, and while the first part of the woods on the lower part of Addington Hills consists largely of birch, oaks are much more plentiful towards Upper Shirley and again there are springs.

Above these outcrops occur the Blackheath Beds, which form a conspicuous escarpment rising out of the woods. It is flat-topped with a slightly northerly slope, and is cut into by a number of short parallel valleys which crenulate the 400-foot contour. These beds are nearly all sands ; with the upper part so thickly charged with pebbles, that, where the turf has been torn away, the top of the ‘ Hills ’ resembles a shingle beach. The pebbles are flint, and are *all* well rounded and beach-hammered, i.e. they show on their surfaces the curved cracks which are traces of the cones of percussion in flint. It was pointed out by the late W. Whitaker that they must have been rolled on beaches for a long time after they had been separated from their source of supply, which was presumably the last Chalk-with-Flints to be washed away from the middle of the Wealden dome. The pebbles are all flint, with the exception that very rarely there is found a smooth pebble, which like the sarsens consists of cemented sand grains. Lower Greensand chert which occurs in the Pliocene beds of the Croydon district is absent from these Eocene beds ; so that the Lower Greensand in the Weald had not yet been exposed when these Lower London Tertiaries were deposited.

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[1] This beautiful open space is officially called Addington Hills, but is usually spoken of locally as Shirley Hills. It is at Upper Shirley.

The little valleys cutting into the edge of the Blackheath Beds merit attention. They have a definite form, with interfluves that are now rounded where they are closely parallel. Whitaker thought that they might have been produced by water flowing on the Woolwich clays underground, and so removing material and letting down the beds above. It must, however, be remembered that the district has several times been under periglacial conditions, and they may have been cut by the melt water from snow on the flat top of the ' Hills.' They are in form, on a small scale, like some of the shorter dry valleys of the South Downs, e.g. Room Bottom near Steyning and the Devil's Dyke.

After the party had secured tea at the Shirley Hills Cafe, they walked to Ballards Way, where a temporary section had been recorded by Mr. Gossling. The old Chalk pit near Ballards Dairy Farm was visited by permission of Ballards Guernsey Farm Dairy. This shows Chalk of the *Uintacrinus* band, together with a little of the *Marsupites* zone above. Fossils from the pit were exhibited as well as a chart showing the shape variations of *Echinocorys scutatus* (Leske) in the various zones of the Chalk. Portions of this echinoid of the shape characteristic of the zone were collected in the pit.

The walk was continued along Ballards Farm Road under the steep Tertiary escarpment now well exposed by recent tree felling, and then across the valley to the Tertiary outlier of Crohamhurst. The Thanet Sand was seen in an old pit at the north-west entrance to the hurst, and at the top of the southern face the view comprising Sanderstead Church (Pliocene) and the dry valley of Croydon were discussed. Descending a steep gully to the south-west an exposure was inspected ; this appears to be the junction of the base of the Woolwich and Reading Beds with the underlying Thanet Sand. At the foot of the hill the party boarded an omnibus for East Croydon Station.

While the party halted at the summit of Crohamhurst, a hearty vote of thanks to the Directors, Messrs. A. J. Bull and F. Gossling, was proposed by Mr. Arthur Wrigley, and carried with acclamation.

NOTE ON THE GEOLOGY OF CARNMENELLIS

By N. J. G. POUNDS, M.A., Ph.D.

[*Received 22nd September,* 1944.]

CARNMENELLIS is a granite boss, some 40 square miles in area, to the west of the Fal and the north of the Helford River. The surrounding sedimentaries are probably pre-Devonian, and were folded in late Carboniferous times. They have been much intruded by veins, many of them mineralised, which trend generally from N.E. to S.W. The granite has formed a series of joints, at right angles to one another, which have had a certain influence on surface features. Small granite inliers lie to the north and west of the main mass. Post-Carboniferous deposits are limited to some Tertiary gravels near Polcrebo, and thick beds of alluvium, some of it stanniferous, in the valleys.

It has come to be accepted that marine erosion is responsible in varying degrees for the topographical detail. In 1908, Barrow attributed the " 1,000 feet " platform of Bodmin Moor to marine abrasion[**1***], and more recently Macar has postulated a platform at 1,200 feet [**2**]. Balchin has described a " staircase " of such platforms in the Camel valley, with their heights at 850-920 feet, 600-820 and 240-285 [**3**]. In West Cornwall, Gullick found platforms at 750 ft., 600 ft., 400 ft. and 180 ft. [**4**].

The following notes are based on a field examination of every interfluve in the Carnmenellis district. These rise in a series of very gently rising steps, each backed by a rather steeper " riser," indicative of the ancient cliff-line. The bluffs in question are sigmoidal, and it is difficult to estimate at what point on the curve the shore line lay [**5**]. It is probably buried by varying thicknesses of soil-wash and " head," and a certain discrepancy is permissible in the estimated heights of any one platform. The platforms noted were :

750 *and* 620 *feet Platforms*. The conformity of summits between 700 ft. and 800 ft. tends to support the idea of a platform, perhaps somewhat below 800 ft. These hillocks curve over at about 650 ft. to a lower platform, whose upper limit may be taken at about 620 ft. At this time Carnmenellis must have been an elongated island, with two small islets to N.E. and S.E. With the uplift of the 620 ft. platform a drainage system was initiated, consisting of streams which rise just below the old cliff line and flow radially across the platform. The island that existed at the 620 ft. stage was apparently without surface drainage, like the Isles of Scilly today. The new drainage system shows a considerable degree of adjustment to the jointing of the granite.

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* For List of References see p. 146.

430 *feet Platform.* This is the predominant land form of the interior of Cornwall. Its upper limit is generally very clearly marked. Unlike the higher platforms, this is not wholly cut in the granite and, where it is widest, lies partly in the sedimentaries. To the north of Carnmenellis, the 430 ft. platform supports the partly granitic island of St. Agnes, whose raised beach is conclusive evidence of the marine nature of the platform.

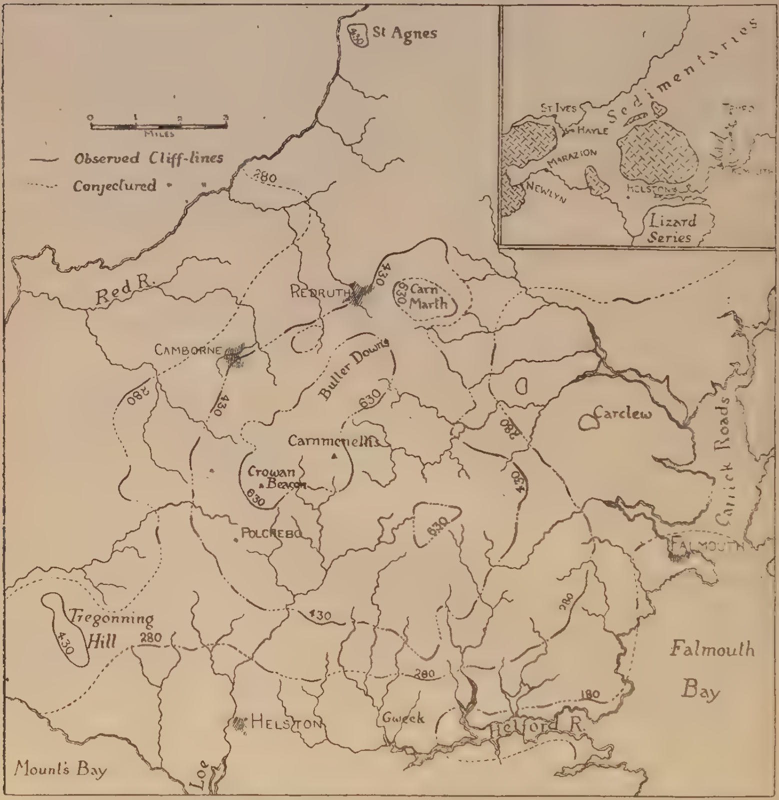

FIG. 7.—HIGH-LEVEL PLATFORMS OF THE CARNMENELLIS DISTRICT. The dotted lines show the upper limit of platforms ; the inset shows the extent of the Carnmenellis and related granite intrusions.

With the withdrawal of the sea from its 430 ft.stage, rivers already developed on the 630 ft. platform were continued across the 430 ft. to the sea at its lower level. These rivers are frequently found on the map to contain an " elbow " near their former mouths. Two factors have influenced this extension of the drainage system, the slope of the newly exposed sea bed and the structures in it, hidden probably by a thin veneer of loose sediment. On the almost smooth surface now exposed the river might be expected to prolong its course in the direction of the steepest slope, which would not necessarily bear any relationship to the river's course above 430 ft. The exposure of the structures of the new platform was similarly likely to deflect the river from its earlier direction. This development of *extended* or *lengthened* consequents is best seen west of Falmouth.

280 *feet Platform.* The 280 ft. platform is not as obvious as the 430 ft., and has not been as widely commented on. In certain places the old cliff-line appears to have been obliterated by soil wash and " head," but on the majority of interfluves there is a recurring feature at about this height. It is also apparent on certain islands to the east.

180 *feet Platform.* This was noticed by Gullick in West Cornwall, but has a very inconsiderable extent, and generally appears as a narrow shelf above the present cliffs.

Raised Beaches. The 60 ft. beach was formerly visible at Penlee, near Newlyn, and there is evidence of it near Falmouth. The preglacial 10 ft. beach is well preserved on the shores of Falmouth Bay.

A belt of land, generally below 180 ft., stretches between Hayle and Marazion, to the west of Carnmenellis. This has been shown to be part of a former river course [**6**], and its topography is consistent with the modification of a former " through " valley by a series of higher sea levels.

The Lizard area was submerged at the 430 ft. level, became an island at the 280 ft. and a peninsula at the 180 ft. The Helford depression, which bears evidence of the 280 ft. and 180 ft. stages, is cut in a belt of relatively soft shales, between the granite and the metamorphic zone of the Lizard. We may assume that, at the 430 ft. stage, the serpentine plateau of the Lizard formed an area of shallow water. On the withdrawal of the sea, a strait would be formed between this and the granite, and on the further withdrawal to 180 ft. a ridge east of Helston served to deflect the rivers and gave them a curvature either S.E. to the Helford or S.W. to the Loe and Mount's Bay. The drainage pattern, so suggestive of river capture, can thus be attributed to quite different processes.

On the north the platforms run down to a steeply cliffed coastline ; on the east is the Fal valley, developed in a sort of " bay " between Carnmenellis and the next granitic mass to the east.

The conclusions may be summarised thus. The topographical forms of Carnmenellis are predominantly the work of marine abrasion, accomplished in a series of stages of diminishing altitude. Within limits the coastline at subsequent stages can be demonstrated by the *plan* of rivers, bends occurring where they pass from one platform to the next. Below such a bend the course of a river is often remarkably straight. This provides an explanation of the singular drainage pattern of the Helford River, which can be explained in terms of a series of lengthened consequent streams.

REFERENCES.

1. Barrow, G. 1908. High Level Platforms of Bodmin Moor. *Quart. Journ. Geol. Soc.*, vol. lxiv, 384.
2. Macar, P. 1936. In *Ann. Soc. Geol. Belg.*, vol. lx, iii, 164.
3. Balchin, W. G. V. Erosion Surfaces of North Cornwall. *Geog. Journ.*, vol. xc, 52.
4. Gullick, C. F. W. R. 1936. A Physiographic Survey of West Cornwall. *Tr. Roy. Geol. Soc. Cornwall*, vol. xvi, 380.
5. Green, J. F. N. 1941. High Platforms of East Devon. *Proc. Geol. Assoc.*, vol. lii, 36.
6. Hendriks, L., in *Geol. Mag.*, vol. lx (1923), 21; P. G. H. Boswell, in *Quart. Journ. Geol. Soc.*, vol. lxxix (1923), 205 ; and H. B. Milner, in *Quart. Journ. Geol. Soc.*, vol. lxxviii (1922), 348.

NOTE ON THE ORGANS OF REPRODUCTION IN SOLENOPORA GRACILIS.

By Prof. E. J. GARWOOD, F.R.S.

[*Received 4th March*, 1945.]

ON reading Dr. Alan Wood's paper on " Organs of Reproduction in the Solenoporaceae," published in our *Proceedings*, vol. lv, part 2, 1944, my interest in the subject was again aroused, and I glanced once more through my sections of *Solenopora gracilis* from Old Radnor. In doing so I happened on a slice which appeared to me to be of special interest in connection with Dr. Wood's paper.

In his photograph—plate 5, fig. B—Dr. Wood has selected one of my slices (No. 394 of my collection) as an example of the " pseudo-sporangia of Garwood & Goodyear." On looking at this slice again I see that it is labelled by us " showing false conceptacles," so that Dr. Wood was justified in using this as an illustration. It was not, however, the slice finally selected and figured as the best example of pseudo-sporangia. This is readily seen by a reference to the figure in plate vi, fig. 1, in the Old Radnor paper.[1] In this section the spaces are seen to be arranged parallel to one another and to the cell-walls and therefore by implication at right-angles to the growth-lines, though they do not rise from any one definite line. It is necessary to make this clear in order to prevent any confusion in the future.

In Dr. Wood's summary, p. 112, he remarks : " Though these facts give support to the theory that the spaces in *S. gracilis* and *S. gothlandica* are sporangial in origin, there are still some difficulties in the way. The first is the different size of the bodies, the second is their arrangement without relation to the growth-lines. They may well be sporangia, but this is still uncertain."

The illustration accompanying this note (Pl. 5) is of special interest in connection with the above quotation. It shows spaces identical in character with those figured in the Old Radnor paper which, like them, lie parallel to the cell-walls, but in addition to this it shows at least four such spaces arising from the same growth-line, while the spaces themselves are arranged approximately at the same distance apart. The three smaller spaces further to the right of the picture may belong to the same series, though only one of these lies on the same growth-line. If they do belong I should be inclined to attribute their fragmentary condition to the section being cut at a slight angle to the central lines of the bodies so as to slope to the right hand and thus to cut through only portions of the original spaces in that direction.

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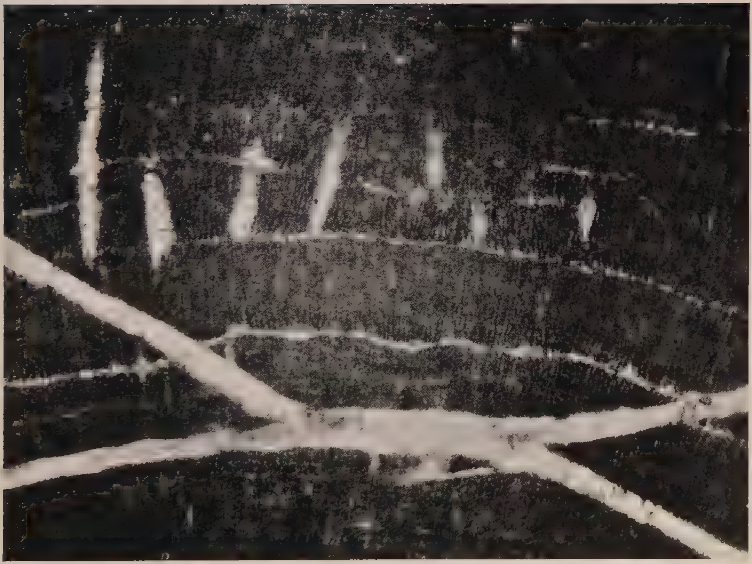
[1] " On the Geology of the Old Radnor District with special reference to an Algal Development in the Woolhope Limestone." *Q.J.G.S.* Vol. LXXIV, p. 1, plate VI, fig. 1.

I do not wish to assert that the section here shown proves conclusively the presence of true sporangia in the *S. gracilis* of the Old Radnor limestone, but I give the section to show—

(a) a case where there is a definite association of these bodies with the growth-lines,

(b) their parallelism with the trend of the cell-walls, and

(c) their regular spacing in the case of the four principal bodies depicted.



Solenopora gracilis, Woolhope, Old Radnor, showing pseudo-sporangia.
X 35.

TERTIARY TURRIDAE AS HORIZON-INDICATORS

By ARTHUR WRIGLEY.

[*Received 17th December, 1944.*]

THE Tertiary Turridae (formerly known as Pleurotomidae) are useful as horizon indicators rather than as zone fossils, because the notion of a geological zone has been elaborated into doctrines which are not found generally applicable to Tertiary strata. In England, the Thanet and Oldhaven sands, the London Clay, the Cuisian and Lutetian Lower Brackleshams, the Auversian Upper Bracklesbams, the Barton beds and the Middle Headons all have their own distinct species of Turridae, which do not pass from one of these main groups to another, while several species are confined to limited horizons within the major divisions. The species with a short duration in time are very restricted in space ; e.g., horizon A3 of the Lower Bartons, only 12 feet thick, has several species peculiar to it, but they are found only at Barton and Alum Bay. When a species persists longer it ranges farther, so that, roughly speaking, area is proportionate to time. Small genera with few species extend less through time and space than the larger genera with many species. Thus, *Epalxis* (3 species) and *Oxyacrum* (6 species) are confined to the Middle Eocene of the Anglo-Parisian area, while *Eopleurotoma* (many species) is world-wide in ranging through the whole Eocene and Oligocene. This strongly recalls Willis' " Age and Area " hypothesis, originally established from botanical data, suggesting that widely distributed species are old ones, while those confined to small areas have originated relatively recently, and so for genera and the larger groupings. A similar notion is that of Ed. Forbes, who remarked that, when a fossil species occurs at very distant localities, the occurrences cannot be contemporaneous, because time must be allowed for migration. From stratal evidence we know that Eocene times were marked by great instability in the boundaries of land and sea and by the appearance of vast numbers of new forms of marine life. Marine species originated and dispersed, but if their sea became dry land before they had time to spread far, they were exterminated. This explains their extinction without recourse to theories of defective adaptation or biological weakness : external chance has played a large part. Statements about the time-range of fossils should answer the questions—where, in what place ? *Trigonia* is Jurassic and Cretaceous in England, but Recent in Australasian seas. Some Turrids are diagnostic of the Middle Miocene in one region and of the Upper Miocene or Lower Pliocene in other areas, and naturally so, for time was required, not merely for their migration but for the migration, so to speak, of the marine facies appropriate to their life. Turrid *species*, generally speaking, are confined to about 100 feet of the sort of sediment familiar in our Eocene sandy clays. One may desire finer divisions, but there must be some limit to the application of Wm. Smith's fruitful idea of strata characterised by their organic remains. Remembering that 25 per cent of the West European Miocene mollusca are still living, these short-range extinct Turrids are surely useful to define horizons in limited areas.

These remarks treat species and genera as natural realities; I was not taught what to look for, and my observations of Tertiary gastropods have fallen naturally into those categories. It seems to me that while an evolution, by some mode or other, is obvious, it has been a process of marked discontinuity, proceeding by leaps rather than in an unbroken stream, as claimed by those who regard our species and genera as purely arbitrary dissections of a continuity.

At the Annual Reunion on June 3rd, 1944, an exhibit was made to illustrate this note and to prove the truth of Fisher's dictum that, like *Ammonites* in Mesozoic strata, the genus *Pleurotoma* affords great help in subdividing Tertiary deposits.

FAUNAL HORIZONS IN THE LONDON CLAY OF CLARENDON, WILTS.

By GRAHAM F. ELLIOTT.

[*Received 1st May*, 1945.]

DURING the winter of 1944-5 the south-west bank of the railway cutting at Clarendon, four miles south-east of Salisbury, was re-sloped and drainage channels constructed, and a fine section of the London Clay exposed, about 500 ft. long and 40 ft. high at the centre. This was kept under observation from December to April, and the following section may be given :—

Top. Soil, etc.
4. Brown clay with *Venericardia*, 12 ft. seen. Scattered ferruginous concretions.
Turritella-bed (4A) near base.
3. Blue clay, very fossiliferous, 6 ft.
2. Septaria with *Panopea*, 1 ft.
1. Stiff dark blue-grey clay seen to 20 ft.
A *Pinna*-bed (1B) occurs at the top, just below the line of septaria, and 6 ft. lower is a bed of large oysters (1A). Large unfossiliferous concretions with outer ferruginous shell occur at the base, just above rail level. This basal clay is glauconitic.

All these clays are sandy, yielding a residue of fine quartz and mica in washings.

The Eocene beds exposed during the construction of this line were described by Prestwich [**1***], and his account was followed by the Geol. Survey in their Memoir on the district [**2**]. From this it would appear that the whole of the beds described above occur in Bed *b* of Prestwich : " Dark bluish grey sandy clays with numerous Panopaeae, Ostreae and Pinnae," referred to the London Clay. It is a matter for regret that the present excavations did not expose the London Clay basement bed or the underlying Reading Beds. A little farther up the line (towards Salisbury) a small disused pit shows the Chalk, and parallel to the railway there was a long excavation for military purposes, now filled in. It is, however, possible to trace the approximate positions of the junction of the Chalk and Reading Beds (with large unworn flints), the mottled Reading Clays, and a sandy horizon at the London Clay-Reading Beds junction. These facts suggest rather less than the thickness of 40-50 ft. allotted to the Reading Beds by Prestwich. A drainage sump taken two feet below rail level at the cutting did not expose the London Clay basement bed, but it may be taken that the section described occurs in the lowest 50 ft. of the London Clay.

An extensive list of fossils from Clarendon is given by the Survey in their Salisbury Memoir [**2**, p. 62], and several *nomina nuda* of Edwards have been dealt with by A. Wrigley in *Proc. Malac. Soc.* subsequently, whilst A. G. Davis is working on the microzoa. It is not proposed to summarise present knowledge of this fauna here, but the following notes may be of interest. Those on the microzoa were supplied by Mr. Davis.

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* For List of References see p. 152.

Bed 1. This clay was relatively barren. Occasional examples of *Ostrea* sp., and (rarely) *Aporrhais sowerbii* (Mant.) and *Natica* sp. were found. Micro-fauna poor : a few foraminifera, ostracods, otoliths and shell-debris.

Bed 1*A*. Several courses of abundant *Ostrea pulcherrima* S. V. Wood, the lower ones with clay-stone filling, the higher ones detached valves. The attached fauna consisted of *Paracyathus crassus* Edw. and H. (common), *Calyptraea* sp., *Conopeum* sp. and serpulids. This bed is rich in well-preserved foraminifera and ostracods, echinoderm spines and fragments of test, minute mollusca, *Dittosaria* sp., and holothurian spicules.

Bed 1*B*. Grey clay crowded with *Panopea*. Numerous examples of *Pinna affinis* J. Sowerby, and many foraminifera and ostracods. *Dittosaria wetherelli* Busk.

Bed 2. Septaria with *Panopea*, *Natica*, *Aporrhais*, etc.

Bed 3. This bed is rich in fossils, both numerically and in variety of species. Most of the rich gastropod fauna described by previous workers would appear to occur here. The preservation is excellent, and sometimes equal to that of a recent shell. The majority of molluscan species from other beds occur here also. Microscopically the bed was extremely rich in foraminifera, ostracods, small mollusca and *Dittosaria wetherelli* Busk ; echinoderm debris and *Ditrupa plana* (Sow.) occur.

Bed 4. *Venericardia planicosta* Lamarck, form *clarendonensis* S. V. Wood, common, often iron-stained. The ferruginous nodules yield small bivalves. Microzoa scarce. This bed seems to show the effects of sub-surface oxidation.

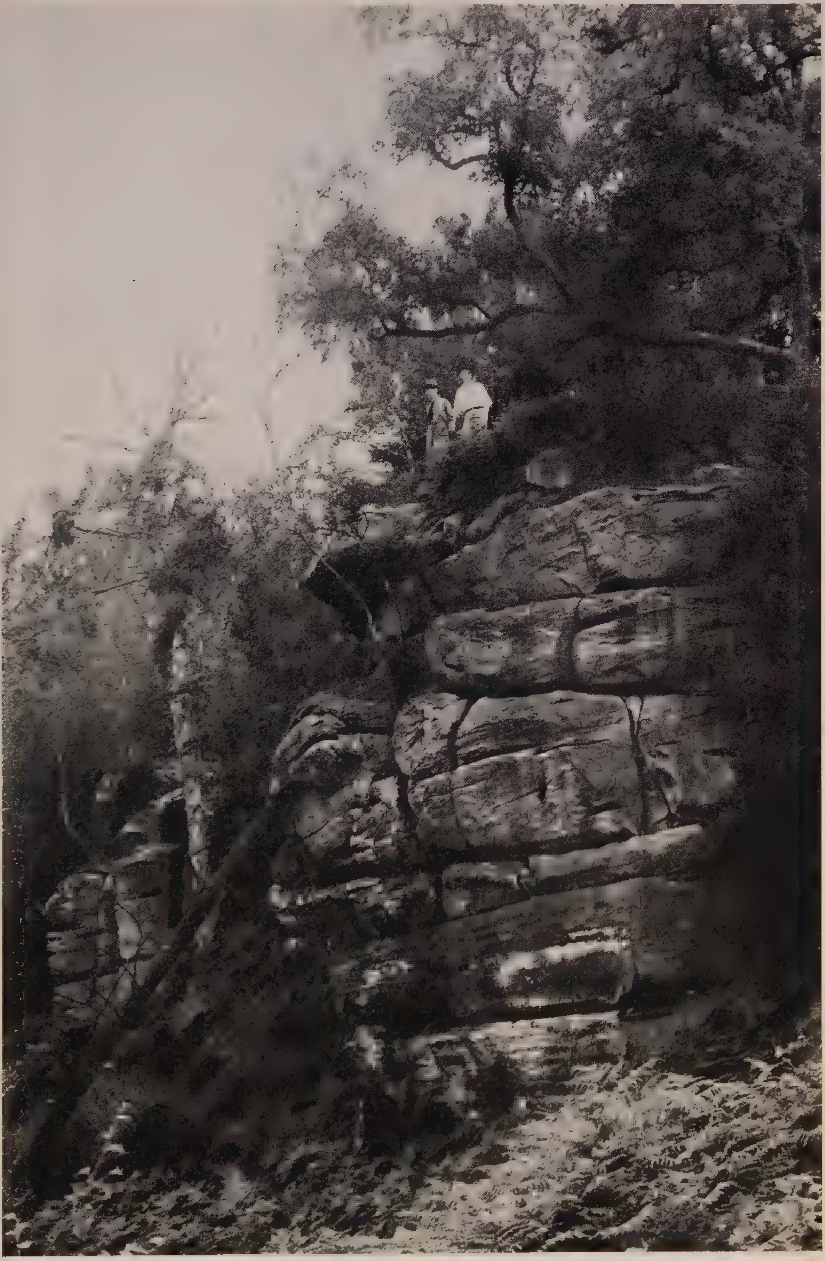
Bed 4*A*. This seam is crowded with broken *Turritella*. At one point a lenticle of lignite with large rounded flint pebbles was found : possibly a drifted tree. Some foraminifera and ostracods occur.

The succession from the lower, relatively-barren, glauconitic clays, through the oyster-beds and associated fauna, up to the rich assemblage of bed 3, is clear ; and with a little experience it is easy to distinguish these faunas by their preservation.

I am much indebted to the Contractors' Agent for permission to examine this section, to Mr. C. Skinner for help on the site, and to Messrs. A. Wrigley and A. G. Davis for their helpful correspondence.

REFERENCES.

1. Prestwich, J. 1850. On the Structure of the Strata between the London Clay and the Chalk in the London and Hampshire Tertiary Systems. *Quart. Journ. Geol. Soc.*, vi, p. 257, Fig. 2.
2. Reid, C. 1903. The Geology of the Country round Salisbury. *Mem. Geol. Surv.*, Sheet 298.



[*Photo by A. J. Bull.*

HARRISON'S ROCKS, GROOMBRIDGE, SUSSEX.

[*To face p. 152.*

FIELD MEETING AT SOUTHBOROUGH, TUNBRIDGE WELLS, AND ERIDGE.

Saturday, 9th June, 1945.

Report by the Director, G. S. Sweeting, D.I.C., F.G.S.

[*Received 25th July*, 1945.]

THE route followed on this occasion was similar to that at the meetings which took place in 1922 and 1933 [**1***, **2**].

The party arrived at Southborough about 11.30 a.m. and proceeded—by the kindness of the Manager—to the High Brooms Brick and Tile Company's pit, where a brief account was given of the geology of the Tunbridge Wells area as a whole. The rocks consist of Grinstead Clay, Lower Tunbridge Wells Sand, Wadhurst Clay, and Ashdown Sand.

Until quite recently the clay division above the sand has been mapped as Weald Clay, and as such it appears on the old 1 in. Geological Survey maps. In 1938, however, Dr. F. Buchan [3] showed by continuous six-inch mapping from Sevenoaks to Tunbridge Wells that all three divisions of the Tunbridge Wells series of rocks persisted throughout the area. Thus " Weald Clay," as mapped by Drew and later workers, is incorrect and really represents the Middle Division of the Tunbridge Wells Sands—*Grinstead Clay*. Buchan states that a few feet only of the Upper Tunbridge Wells division is present in Tunbridge Wells itself, most of the rock having been removed by erosion.

On entering the High Brooms pit an excellent section, about 100 ft. high, was seen showing an almost perfect junction of the Lower Tunbridge Wells Sands with the Wadhurst Clay. The lowermost sands are thinly bedded and silty in contrast to the massively-bedded " Sand Rock " nearer the top of the pit. The thickness of the Lower Tunbridge Wells Sand in the area is about 140 ft. The Wadhurst Clay has a maximum thickness of about 175 ft. and consists of alternations of shaly beds and dark blue clay with thin bands of Tilgate Stone (calcareous grit) and ironstone nodules. In the shales, species of *Cyrena* and *Unio* were collected, together with many plant remains—*Equisetites*, etc. Excellent examples of ripple marking were also seen.

Leaving the pit, the party proceeded westwards via South View Road to Powder Mill Lane, where in the eastern bank—just before entering the main road—the Sand Rock is well exposed. Attention was called to its massive character, jointing, current bedding, and differential weathering.

Continuing westwards, the main road to Tunbridge Wells was entered and an abrupt change in topography was observed, hilly ground (390 ft.) giving place to a broad flat area. Here it was shown that a strike fault occurred in which a large mass of Grinstead Clay had been let down against the Sand Rock.

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* For List of References see p. 155.

Lunch was taken in Tunbridge Wells, after which the route lay over the Common, where large weathered masses of Sand Rock were seen ; these showed all the characteristic lithological features common to the rock, together with some thin pebble beds. From here the party proceeded via Hungershall Park, crossing, near B.M. 280.3, the junction of the Wadhurst Clay with the Tunbridge Wells Sand. A halt was made in the lane leading to Cold Bath Farm, where, in the stream bed, yellow-blue mottled Wadhurst Clay was seen. Returning to the main road the Tunbridge Wells Sand occurs, on the northern banks, in juxtaposition with the Wadhurst Clay and is faulted down against the Clay. The effect of strike faulting of this type is responsible for the presence of most of the chief valleys of the district.

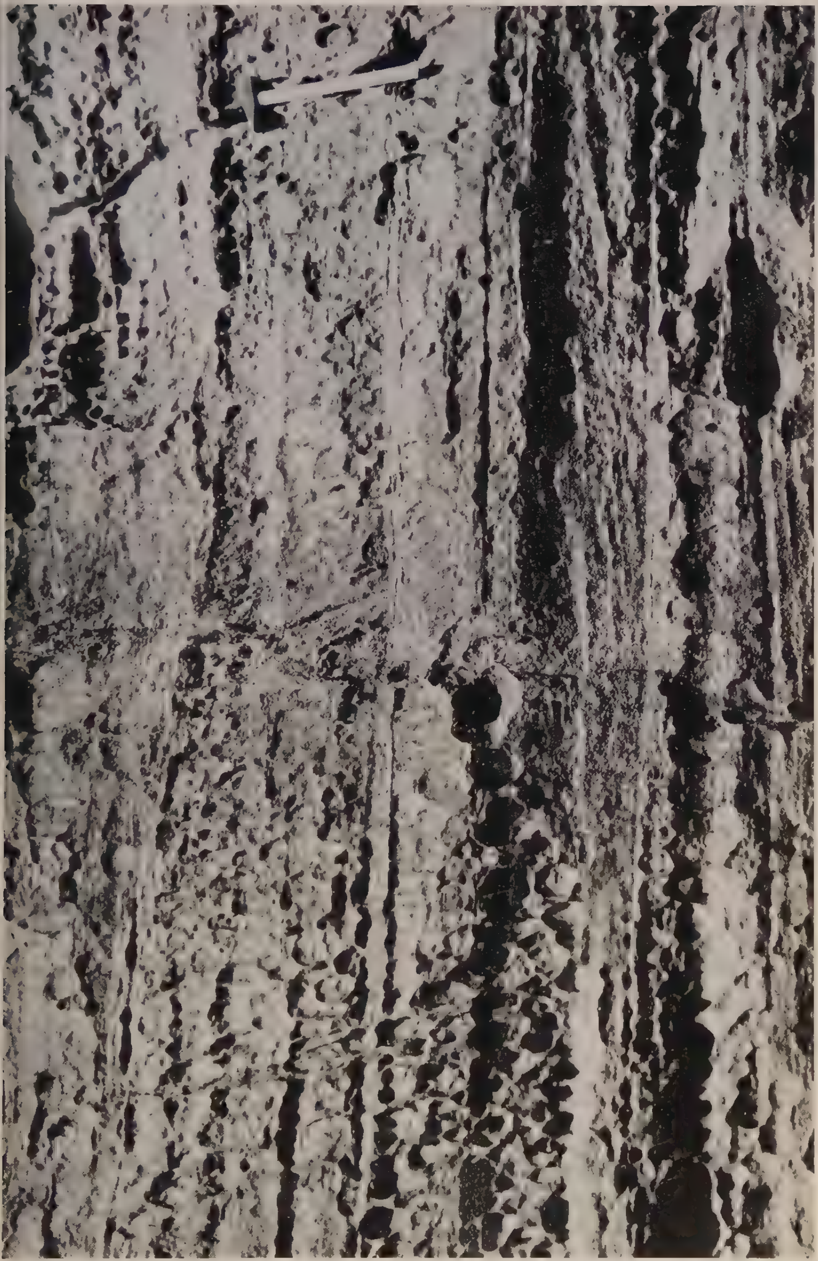
About a quarter of a mile to the west the High Rocks were reached. Here the Sand Rock occurs as imposing cliff-like masses, about 50 ft. high, exhibiting deep, wide, open joints. The rocks also show extensive undercutting with excellent examples of honeycomb weathering. The customary discussions on the origin of this weathering took place, some members of the party being of opinion that both mechanical and chemical agents had taken a combined part in producing this phenomenon.

From High Rocks the traverse continued over Broadwater Forest, an area occupied by Tunbridge Wells Sands, richly vegetated and picturesque. On reaching Park Corner the party proceeded along the private road leading to Forge Farm and Harrison's Rocks. Attention was here called to the road-metal, which includes iron-slag derived from the old Wealden iron furnaces, at one time so common in this district. Three hundred yards along the road at Pinstraw Farm another strike fault was crossed, where Grinstead Clay again occurs faulted down against Lower Tunbridge Wells Sand.

At Harrison's Rocks, cliff-like outcrops of sand rock similar to those at High Rocks occur. Here, jointing and honeycomb weathering is again seen to perfection. The "cliffs" average 40-50 ft. in height and rise almost sheer from the small alluvium plain in the valley below Groombridge. Plate 6 shows the general character of these rocks, and Plates 7 and 8 illustrate excellently the honeycomb weathering and "stalactitic" forms which occur along the bedding planes in the weathered portion of the rocks.

From Harrison's Rocks the party walked to Eridge Station along the east-west road bounding the railway. On the south of the road, Ashdown Sand was seen on the hillslopes and also in the road-cutting near the Station. The Ashdown Sand is here faulted along the valley, first against the Tunbridge Wells Sand and then against the Wadhurst Clay.

Tea was taken at the Railway Inn, Eridge, after which some richly fossiliferous Ashdown Sand, containing casts of *Cyrena*



HONEYCOMB-WEATHERING IN HARRISON'S ROCKS, GROOMBRIDGE.

[*Photo by A. J. Bull.*

[*To face p. 154.*

and *Unio*, was obtained from Bowle's Rocks about three quarters of a mile due south of Eridge station. This fossiliferous section is now being investigated by Mr. J. A. G. Thomas, who found the horizon.

The excellent illustrations of Harrison's Rocks are the work of Dr. A. J. Bull, and (to the writer's knowledge) are the first detailed photographs to be published of this imposing outcrop of Tunbridge Wells Sand.

Dr. G. W. Himus acted as Secretary for the meeting, and many thanks are tendered to him for the very efficient services he gave throughout the day.

REFERENCES.

1. MILNER, H. B. 1923. Report of Excursion to Southborough, Tunbridge Wells, High Rocks and Eridge. *Proc. Geol. Assoc.*, vol. xxxiv, p. 54.
2. ———. 1933. Report of Field Meeting to Tunbridge Wells, High Rocks and Eridge. *Proc. Geol. Assoc.*, vol. xliv, p. 447.
3. BUCHAN, S. 1938. Notes on Some Outliers of Grinstead Clay around Tunbridge Wells, Kent. *Proc. Geol. Assoc.*, vol. xlix, p. 407.

THE EARLY DIGS IN KENT'S HOLE, TORQUAY, AND MRS. CAZALET.

By A. S. KENNARD, A.L.S., F.G.S.

(*Presidential Address delivered* 3*rd March*, 1945.)

[*Received 31st May, 1945*]

I. FOREWORD.

THE story of the first systematic exploitation of an English cave deposit by the Rev. J. J. Mac Enery and others has been told many times and the literature relating to the digs is very extensive and from the modern viewpoint much of it is verbose, but one must remember the background of the period. What are axioms in geology today were then fiercely contested and had to be proved up to the hilt. Geology was not received with open arms, for it was and is a revolutionary science, upsetting all the old-established views as to the age of the earth, and " there is no pain so great as the pain of a new idea." Those of us who can remember the " Eolithic " controversy can recall how fierce was that dispute, whereas today Man is postulated as living in Pliocene or even Miocene times, and the statements are received with complacency. However, by 1820 the greater antiquity of the earth, but not of man, had been accepted by those who took an interest in such matters. In this country they included the learned professions and the cultured men of leisure with a much larger proportion of the peerage and the country gentry than is now the case.

In 1823 Buckland published his *Reliquiae Diluvianae* and the Pleistocene chapter of geology was begun. For the period it is an excellent work and still repays reading. It had a wide circulation with great influence and cave digging became quite a fashionable pursuit. After reading this book T. Northmore commenced digging in Kent's Hole in 1824, and had several digs there. In the following year Buckland and Sir W. C. Trevelyan also dug there as well as Mac Enery. The latter's real work probably began in November, 1825. The main outlines of the subsequent story are as follows : From 1825 onward Mac Enery continued his diggings. He intended to publish a book entitled " Cavern Researches," with 30 plates embodying the results of his work in Kent's Hole and other caves in the neighbourhood, but although a prospectus was issued and 18 plates drawn on stone by G. Scharf, the book was never finished. Mac Enery died February 18th, 1841, and the following year his collection was sold by auction and scattered. Though he published nothing himself, the results of his work, especially the fact that he had found human artifacts in association with the bones of extinct mammals, became widely known through various sources. The bitter controversy that followed is now quite forgotten, but the subject appealed to all intelligent folk so that it is no wonder that Kent's Hole became famous. In addition the presence of *Machairodus* was so startling that its provenance was challenged, though in justice to the great palaeontologist who did so on *a priori* grounds he at once admitted his mistake when he saw the specimens. However much it is out of place, there it is and its presence has to be explained.

Since all the non-marine mollusca found during the various digs had been thrown away as useless I had paid but little attention to the site, though I had visited it on several occasions and grieved over the lost opportunities. In 1938, however, I had the pleasure of working over the extremely fine series of bones and flints, many of them figured by Mac Enery, in the Geological Survey Museum (*ex* Geol. Soc. Coll.), which came from Mac Enery's dig. This necessitated a collation of all the available data, and here I was fortunate for Pengelly had already published nearly all the evidence in his series of papers entitled " The Literature of Kent's Cavern " [**30, 31, 37, 45, 51***], in which he had printed or reprinted every scrap of information that he could find or hear of, for he and his willing helpers had searched every available source. Since many of the originals are in works difficult of access and the *Transactions* of the Devon Association are not in every library, the pertinent facts are given in an appendix.

It was soon clear that a number of mistakes had been made and repeated and one or two chapters of the story had been overlooked. Mac Enery apparently made but few contemporary notes and relied mainly on his memory, though, of course, it is possible his notes were destroyed. There are very few dates in his MS., but it is possible by a collation of these with outside evidence to build up a fairly complete story. Owing to the present conditions some points are left unsettled, but it has been considered advisable to place on record what has been done and leave it to others to complete the work.

The cave itself has been called Kent's Hole, the local name, as well as Kent's Cave, Kent's Cavern, Kent's Hole Cave and Kent's Hole Cavern. Mac Enery often used the local name derived from an owner in the 17th century. Cave and cavern are modern literary words ; hence I have used the traditional name. Mac Enery's name has also been rendered in several ways for there is no standard for writing the non-English " Mac." He himself always signed McEnery and it is thus spelt on the plates, but that may have been for brevity. On the prospectus it is Mac Enery, and this I have used, but in my quotations from the literature the name is copied as originally given. Explanatory matter is always in square brackets. Though I always speak of " Mac Enery's digs " this is only for brevity, for I think I have shown that though he was probably the inspiring figure, yet he was helped by the Cazalets, a feature which has been quite overlooked. As in my previous papers I have been greatly helped by many kind friends, and I would mention C. P. Chatwin, A. G. Davis, J. F. N. Green, F. N. Haward, M. A. C.

Hinton, Dr. A. T. Hopwood, Dr. J. W. Jackson, A. H. Ogilvie, Dr. C. J. Stubblefield, S. Hazzledine Warren, and Sir Arthur and Lady Smith Woodward, for without their kind help this address could not have been written.

Finally, I must pay tribute to the memory of W. Pengelly for the great care with which he placed on record so much of the evidence which I have used and to the authorities of the Geological Survey for the facilities they so freely gave me during a very worrying period to all custodians of books and specimens.

II. THE MAC ENERY COLLECTION.

This was sold by auction in 1842 and widely scattered. Dr. König made many purchases on behalf of the British Museum. Owen notes " some of the rarest and most valuable of this gentleman's (Mac Enery) collection have been lately acquired by the British Museum " [**15**, p. 103]. These have been catalogued by Lydekker [**53**]. The lots fetched high prices for W. C. Radley, a dealer who was present at the sale, has stated " the worst tooth at Mr. Mc Enery's sale brought a shilling " [**42**, p. 249]. It is interesting to note on the same authority " what he [Mac Enery] valued most was a sucking tooth or milk tooth of an elephant calf, which he valued in £10 and kept wrapped in cotton wool " (*op. cit.*, p. 248), but I do not known what it fetched. The Geological Survey apparently made no purchases and the very fine series in their Museum mostly came from the Museum of the Geological Society. Apart from Mrs. Cazalet's donations there are three series : 1, given by W. Long, June 16th, 1847, and containing many figured specimens. This series was bought by Mr. Lear at the Mac Enery sale and was sold by him to Mr. Long just previous to the donation ; 2, a series bought by a syndicate of the Fellows at the Mac Enery sale ; 3, a series from the Pengelly Coll. given to the Museum of Practical Geology by Miss Pengelly. There are other good series at Torquay and Exeter, whilst Oxford has the Buckland Coll. This may also include a missing series for Mac Enery has stated that he sent a series to Prof. Buckland for the London G[eological] Society (Appendix), for the only recorded donation was on October 12th, 1826. " Cast of the tooth of *Ursus cultridens* from Kent's Hole " (*Trans.*, Geol. Soc., Lond., Series ii, vol. ii, list of donations, unpaged). This is the first record of this species [*Machairodus latidens* Owen] from an English deposit. The series given to the Paris Museum by Mac Enery is probably still there. It certainly was in 1901, as noted by M. Boule [**60**]. Mac Enery also gave series to Bristol, York and *fide* Northmore to " Plymouth and other provincial towns " [**7**].

The J. E. Lee Coll. was given to the British Museum (Nat. Hist.) in 1885 and " contained 106 original specimens of Mc Enery from Kent's Cavern bought at Newton " [**64**, p. 308]. Unfortunately these specimens were given too late to be catalogued by Lydekker [**53**]. Mac Enery gave to the British Museum a series in 1830, but the specimens were not differentiated by Lydekker. A purchase by the same Museum of "Mammalian remains from Kent's Cavern" from Heggerty in 1843 [**64**, p. 308] calls for extended notice. I have seen no detailed list of this series, and one might easily infer that they came from the Mac Enery sale of the previous year, but C. Carter Blake has described a number of human bones from this purchase [**25**]. He concluded that they had "lain loosely on the floor of the cave where they have become coated with small portions of stalagmite without being imbedded in substance" and "no antiquity can be assigned to the remains." Pengelly has the following note : "Heggerty resided at Torquay for some years, where he dealt in fossils and minerals. He for some time acted as one of the guides to Kent's Cavern, having been appointed by the proprietor the late Sir L. V. Palk Bart. He removed to London about 1842" [**37**, p. 487]. Blewitt in 1832 stated "The persons appointed Guides to the Cavern are J. Heggerty, mineralist on the quay, and Geo. Pearse at Tor ; to whom the keys are entrusted. No one is allowed to dig without permission of Sir L. V. Palk [**7**, p. 107 note]. One can safely conclude that these specimens were the result of "private" digging by the "watchdog."

Pengelly has noted that in his diggings in the "Charcoal Cave" he came across some fragmentary human bones and two teeth, fragments of pottery, etc., and he adds "As earlier explorers of the cavern had in one place in this cave attempted to break through the Stalagmitic floor at a point further in than the spot occupied by the black material, and must have frequently trampled on it, there is no difficulty in accounting for the broken condition of the pottery, the charcoal, and most of the bones" [**51**, p. 323] ; Busk's report on the bones is on the next page. It is probable that Heggerty's specimens came from this site.

Other specimens in the British Museum (Nat. Hist.) that are almost certainly from the Mac Enery Coll. are thos *ex* "Enniskillen Coll." and a series given in 1845 by the Rev. Upton Richards. At the same time it must be remembered that quite a number of other people were digging contemporary with Mac Enery and later, and he names two, the Rev. L. Welland and the Rev. Mr. Belfield. There was also in the Museum of the Royal College of Surgeons a series given by Gerard Smith prior to 1845, which may well have come from the Mac Enery sale, and the canine of *Machairodus latidens* figured by Owen which certainly did, but what has happened to these I cannot say. Mac Enery often wrote "Kent's Hole" in ink on his specimens ; a useful precaution, since he dug in several caves, and one that may give a clue in future work. Dr. J. Wilfrid Jackson has noted in his valuable *Schedule of Cave Finds* [**83**, pp. 18-21] that in the Royal Library and Scientific Institution, Bath" other remains of special interest from the Rev. Mc Enery collection, with Lonsdale's writing preserved on the labels" (*op. cit.*, p. 19). Since Lonsdale left Bath in 1829 these are probably not from the Mac Enery Sale 1842 and may be an unrecorded donation from Mac Enery. The series noted by Mac Enery as being in the possession of Sir Lawrence Palk [**31**, p. 250-62] was probably given back to Mac Enery ; the lion's jaw certainly was. No information is forthcoming as to Mrs. Cazalet's "very fine" collection and the "Welland" and "Belfield" Colls. are also untraced.

The eight specimens of jaws of hyaena bequeathed by Sir W. C. Trevelyan to the British Museum (Nat. Hist.) [**64**] were in all probability found by himself, for he is known to have dug there on two occasions at least.

III. MAC ENERY'S MANUSCRIPTS.

Vivian states "The manuscript was purchased in a lot of sermon notes and other papers by the late Mr. Lear of Lawrence Place. It was for many years overlooked and supposed to be altogether lost to science . . . . Having accidentally discovered that the greater portion of the Memoir was in the possession of Mr. Lear I published some extracts in the "Torquay Directory" with reports of Lectures which I delivered before the Natural History Society. It was subsequently purchased with Mr. Lear's cabinet of fossils by W. Long, F.G.S., who most liberally presented it [the MS.] to me, with a view to the publication" [**22**, preface]. Through the kindness of A. H. Ogilvie the reference to the *Torquay Directory* has been verified. He says that for the first five years it was only a Directory, but in 1846 and onward it gave a certain amount of news and in the issue of Wednesday, April 12th, 1848, the following notice appeared.

"Torquay Natural History Society. On Tuesday the 4th inst. Mr. Vivian delivered a lecture on 'Kent's Cavern' in the Society's Museum. The following is an abstract of what he considered to be the origin of the cavern, and the changes which had occurred in the different stages of its history . . . . Several interesting extracts were read from the unpublished memoir of the late Rev. J. Mc Enery and the lecture was illustrated by specimens from the cavern. Mr. V. expressed his regret at not being able to exhibit the plans and drawings of the cavern to which reference had been made, as they were still in London where they had been sent to be engraved for the purpose of illustrating a paper which he had communicated to the Geological Society and which was to appear in their *Transactions*." Vivian has muddled his notes badly. His paper was read before the Geological Society May, 1847, and its publication was suspended until the facts could be verified by Buckland, but an abstract was published in the *Proceedings* for that year [**16**]. Alas for Vivian's hopes between that date and 1856 when Buckland died, the latter never had time to make the visit, and in all probability the paper and plans are still waiting in the archives of the Society. The known facts are as follows. The papers were bought by W. Lear as well as many bones at the Mac Enery sale in 1842. At an unknown date both were bought by W. Long, who, on June 16th, 1847, gave the bones including 24 figured specimens to the Geological Society. At a later date the same donor gave the MS. to Vivian, who, in turn, presented them to the Torquay Natural History Society where they still remain.

One can thus say that Vivian's statement that the MS. "was for many years overlooked and supposed to be altogether lost to science" is an exaggeration. At the most the time was less than five years.

It seems a pity to destroy the romantic legend, but the facts are against it. Vivian's other statement that the MS. were bought "subsequent" to his lecture is also incorrect; they were bought the year previous.

In 1859 Vivian published the well-known *Cavern Researches* "compiled from the original manuscript notes of the late Rev. J. Mac Enery," an attempt to make it a consecutive narrative mainly based on Fasciculus A. In this he was successful so far as a narrative, but it is decidely misleading and there are many needless alterations of the text [**22**]. Finally in 1869 Pengelly published the whole of the MS. relating to Kent's Hole, omitting the other caves, with copious notes, some of them corrective, in every way a scholarly piece of work [**31**, pp. 189-482].

The reprint was repaged 1-310, so both paginations are cited. It is a matter of deep regret that he did not make a critical comparison of the various Fasciculi, for with his knowledge and sources of information it would have been much better than what I have been able to do. Pengelly gives four good reasons for printing the whole of the MS., and his third reason must be quoted. "By printing *in extenso* the best opportunity will be given for forming an opinion respecting the extent and variety of the author's reading, his mental powers and acquirements, his prepossessions and besetments, and the influences by which he was surrounded" [**31**, p. 201-13]. To understand Mac Enery's work properly one must study this paper which is rather inaccessible.

To speak of the MS. as that of Mac Enery's projected work is misleading. Pengelly describes it as follows: "The manuscript was probably written at intervals extending over several years. Some portions of it are certainly not older than the year 1836, as Dr. Buckland's Bridgewater Treatise, published in that year, is quoted several times and no portion can be assigned to a later date than 1840 as the author's decease took place on February 18th, 1841. It may be said to consist of ten fasciculi which I have designated A, B, C, D, E, F, G, H, I and J. The last consists of a series of scraps, notes and memoranda. The others take the form of separate narratives or essays in which the Cavern and the discoveries made in it are described and their bearings on Palaeontology, Archaeology, Anthropology and Theology are discussed. They are all in a more or less imperfect condition" [**31**, p. 199-11]. It really represents an accumulation made by the author over a number of years, the results of several attempts to write the story as the accumulation of extraneous facts made his early attempts incorrect, part of the MS. being destroyed and the remainder kept.

Fasciculus J appears to contain fragments of still earlier attempts than those that have been preserved better. Though Pengelly printed the papers he never pointed out the contradictions in them. but he did print them and thus made them accessible to all students. If one only had Vivian's version it would be impossible to arrive at the truth. In the following notes I have used Pengelly's division into fasciculi and have given the really relevant facts, and the references are to Pengelly's reprint **31**.

Fasciculus A.

This is certainly the most complete, though there are many intentional gaps left, to be filled in later, such as the measurements of the various chambers of the cave and most of the references to the plates, and the latter have been filled in where possible by Pengelly in his notes. There is but little mutilation, and this is usually obvious from the context, but this mutilation shows that it was not the final version. There are 33 headings which need not be repeated, and he gives accounts of the origin of the work, the geology of the district, a description of the cave and of his diggings, and theoretical conclusions as to the origin and causes of the contained deposits. Allowing for the background of the time it is an excellent piece of work and will always remain as proof of his wide reading and determination to master the subject. With the possible exception of Buckland there was no other man in England who could have written it, and Buckland, alas, was fettered by his theory of the "Universal Deluge." Buckland's Bridgewater Treatise, 1836, is quoted several times, Dr. Schmerling's work on the Belgian caves, 1833, is frequently cited and he also notes a visit to Cuvier in 1831. With regard to this visit Mac Enery states: "M. Cuvier to whom I submitted the fragment in 1831 was struck with the form of the jaw [Homo]—he pronounced it belonged to the Caucasian race. He [promised] to bestow particular notice on it, but death unhappily for science, put a stop to his glorious labours. [Cuvier died May 13th, 1832]. All the specimens, with a collection of fossil bones, the third I had presented to the Museum of the Jardin des Plantes, I transmitted to him before I quitted the Continent and may be found among his effects" [p. 222-34]. Though "submitted" is vague, the last remark shows that the human jaw was shown personally to Cuvier. From the above facts it is clear that fasciculus A was not written before 1836 and the probability is that the date is 1837 or later.

Under the heading "Occasion and results of my first visit," Mac Enery describes a visit in the summer of 1825 in a party of a dozen persons including Capt. Welby and Mr. Northmore. He is very emphatic in saying it was his first visit and describes his feelings. He, however, left the party and had a dig on his own and was successful in finding some bones, but concealed his good fortune from the others, since he wished to send the specimens to Oxford, *i.e.*, Buckland. The bones, including a jaw of Hyaena, were duly sent and a selection was drawn on stone by Miss Morland [**31**, pp. 208-10, 220-22). For the plate see p. 183. This visit was in October according to the legend on the plate, and not "Summer."

Mac Enery had, however, preserved three versions of an earlier visit with Buckland and Northmore, which was in the summer of 1825 [pp. 441-3/269-71, 339/151]. He has telescoped the two visits into one and this previous visit will account for his desire to send any specimens found to Buckland. Mac Enery also states " In addition to specimens of the five species figured in Mr. W. C. Trevelyan's plate there appeared several new ones belonging to Horse, Deer, Hare, Rabbit, entire head of Field Rat (campagnol) and a small feline or cat—with the bones of two species of Bird " and " the upper jaw of a Hyaena, the bone of which was eaten away close to the roots of the teeth, and even the upper portions bore impressions of gnawing " [p. 210-22]. Since Trevelyan's plate was published in 1825 it is very likely Mac Enery had seen it, but if the above remarks are really contemporary views and not afterthoughts he was very far from being a novice in Vertebrate Palaeontology.

Among the many interesting facts in this fasciculus one may note that when Mac Enery first found the worked flints he was certain that they were contemporary with the extinct mammals " and I communicated my impressions to Dr. Buckland with all the earnestness of sincere conviction " [pp. 226-38]. " In this loose heap it was that I found the first Rhinoceros tooth which I presented to a lady at Torquay, who had a collection of objects of natural history from the environs of Torquay—I had not yet commenced forming my own collection " [p. 236/148]. The lady was presumably Mrs. Cazalet and the finding of the Rhinoceros tooth is decribed in Fasciculus J. [pp. 441-444/269-272[. It was found on his real first visit.

That the fractured jaws of *Ursus cultridens* [*i.e.*, teeth] occurred on the outskirts of the Bear's Den [p. 243/55]. Mac Enery gives a list of helpers. He names Viscount Valentia, Mr. Henry Maxwell, Lord James O'Brien, Lord Newark, Lord Henry Carr, Dr. Beeke the Bishop of Bath and Wells, Rev. Dr. Cooke of Gloucester, Dr. MacTurk of Glasgow, Mr. W. C. Trevelyan, Sir T. Ackland, Marquis of Northampton, Mr. Curtis of Teignmouth, Mr. Croker of Bovey, Rev. Mr. Lyte, Rev. Lawrence Welland, Mr. Featherstone of America, and on several occasions Dr. Buckland [p. 249/61]. It would indeed have to be a great geological find nowadays to attract such an assemblage. There are only fourteen references to plates, since there is no palaeontology. This was reserved for a later part. This fasciculus may be summed up as a draft for the first part of *Cavern Researches*, and since the date is probably 1837, the latest attempt. It provided by far the greater part of Vivian's publication and occupies 61 pages in Pengelly's paper [**31**].

Fasciculus B.

This occupies 38 pages in Pengelly's paper and has suffered far more mutilation than A, all duly noted by Pengelly. The first ten pages had been destroyed and it has the appearance of being unfinished. A description of the cave and the deposits is given as in A, but differing in the arrangement, but it covers far more ground for pottery, human bones and Druidical temples are discussed. When this was written he was still under the influence of Northmore. All the measurements of the various divisions of the cave are given and their total absence from A would lead one to infer that he intended to make a fresh survey and not rely on his past records.

One notes the following statements : " The outside of the left entrance was cleared away by the directions of Mr. Northmore." " I was present at the opening of the mouth." " This was about three years after I had opened under my own eye and partly with my own hands—many cartloads of similar loose stuff to the outward filling " [p. 264/76]. This looks as though it were written in 1829, and that Northmore was still digging at that date.

" In the midst of these I beheld a profusion of small chippings of flint, with a few well-formed arrow heads and blades—my astonishment could not be exceeded except by the perplexity into which the scene threw me—I instantly covered up such of the flints and bones as I had not disturbed in their situation and I desisted for the day—instantly on my return I took up my pen with the determination of announcing the anomalous discovery to Dr. Buckland (whom I promised to apprize of the next discovery of flints)." Mac Enery, however, examined the human bones found with the flints and resumed his dig the next day, found more bones and flints and from their position he rightly concluded they were not contemporary with the extinct animals [pp. 278-9/90-91]. But Mac Enery had found a flint artifact in an earlier dig (summer of 1825) and Buckland one before that of which apparently Mac Enery was unaware. " Mr. Northmore possesses a piece of wood shaped like a sandal which was found by Mr. Braham, watchmaker. The latter states that he extracted it from the lower deposit of mud." He then goes on to show that from its condition it could not have come from that level [pp. 284-5/96-7]. This shows that Mac Enery was a keen observer. In Fasciculus A this " Druid Sandal " is said to come from the black mould and no mention is made of its presumed antiquity [p. 209/21].

" On the other hand many fine and delicate specimens among which was *U. cultridens*, were found quite uninjured in the midst of the shattered bones." " The enormous aggregation of remains including the new species of *Ursus cultridens* in this retired branch." " The tusk was fractured and further crushed beneath the mass—a piece of about a foot long was extracted tolerably perfect." [p. 294/106].

This last probably refers to the fragments given by Mrs. Cazalet to the Geological Society, still with her label " We think this is fossil ivory, etc." " Hitherto I labored alone with a pavior's pick—I now proceeded to excavate occasionally assisted by persons of great intelligence and experience——half a dozen workmen properly appointed labored hard in cutting away the crust which was firmly cemented together " [p. 283/95]. Alas, he gives no names nor a date. One would, however, suggest that this was late in 1825 after he had received Buckland's report on the bones found in October of that year and probably urging him to continue the work. Several pages at the end of this fasciculus had been originally left blank and Mac Enery has used them for accounts of two digs, one on August 14th, 1829, and the other on August 19th He was accompanied by "Master Aliffe," one of his workmen, and he gives a good description of finds in the "black mould," but the exact location in the cave is not stated. The account, which runs to four pages, is too long to give here and should be consulted [pp. 295-300/107-112], but the archaeological evidence which was then destroyed is painful reading and the relics are either scattered or lost. There are only seven references to the plates, but this shows that this fasciculus cannot be earlier than 1828. One can safely say that it is an early version of part of Mac Enery's projected work and that the date is probably 1829.

Fasciculus C.

This occupies thirty-eight printed pages. Pengelly states: "The author designated this Fasciculus 'No. 2.' From its 'Index' it commenced with page 73. This, with the exception of the merest scrap, has been torn off and is missing. Of 'No. 1' a few fragments alone remain. Among them is the 'Index' showing that No. 1 extended from page 1 to page 72" [p. 301/113 note]. It is thus another attempt.

It commences: "I recovered from the effects of my imprudence visible in my altered health." His "imprudence" is described in Fasciculus A [p. 233/45] and Fasciculus J [p. 451/279]. There is an imperfect account of the cave and a long and valuable dissertation on the flints extending to nearly half of the fasciculus.

One notes the following :—

"It was in this bed I discovered the Rhino tooth alluded to among the discoveries of my first search with Dr. Buckland" [p. 303/115]. This is also noted in Fasciculus A [p. 236/48]. He quotes Captain Sykes' account of a recent Hyaena den from the *Edin. New. Phil. Journ.*, 1827 [p. 305/117].

"The annexed section will indicate the relative position of the alternating strata of stalagmite and loam" [p. 311/123]. This section has been preserved and has been published by Pengelly [facing p. 311/23]. It is quite a good section and shows clearly that to dig a cave by "foot" levels may be very misleading. Mac Enery gives the essence of the dated notes at the end of Fasciculus B showing that this is later [p. 329/141].

He criticises an unpublished theory of Buckland to account for the presence of the flints [p. 334/146]. He states: "In this superficial bed I have detected Flint relics and I have been assured by a Revd. Gentleman that he has found them in great abundance there—but on the occasion of Dr. Buckland's last visit we were not so fortunate as to find even one, notwithstanding the removal of large masses of this bed, by the Revd. Gent. himself and the rest of the party." [p. 336/148.]

"If they [the flints] had been found only in decidedly modern mould, or even of mixed character, there would be an end to the controversy—but the fact of their occurrence in the lower bed in still greater number than the upper sets the matter at rest. [p. 336/148].

"I have identified the flints with similar relics preserved in different museums in England and France—those especially which are in the British and in the museums of the Jardin de Plantes and of Boulogne sur mer—" [p. 324/136]. Mac Enery certainly visited Paris in 1831, so this fasciculus cannot be earlier than that year.

"I had taken this view of their position and history some years ago—I have employed the interval in carefully investigating their locality" [p. 328/140]. This shows that the fasciculus is not an early one.

"But to this Dr. Buckland replies that he possesses a human bone, but is uncertain as to its precise locality" [p. 333/145.] This may be at Oxford.

"It is painful to dissent from so high an authority [Buckland] and more particularly so from my concurrence generally in his views of the phenomena of these caves, which three years' personal observation has in most every instance enabled me to verify" [p. 338/150]. This can be interpreted in two ways.

It may mean that the paragraph was written three years after he commenced his dig, i.e. 1828 or 1829, or it may mean that his systematic digging lasted three years. There is also the possibility that it may have been "spatchcocked" from an earlier version. Hence no deductions can be based on the paragraph. Fasciculus C on the above evidence may well be dated as not earlier than 1831, and was kept for the facts to be incorporated in another version which did not materialise. There are only three references to the plates.

Fasciculus D.

This is quite different from those already dealt with and is palaeonotological. It occupies fifty-three pages in Pengelly's printing and has suffered but little mutilation. Pengelly states "according to the 'Index' it extended to 'Page 123' and contained descriptions of Weasel, Badger, Hog, Hare, Rab., Lagomus, Rats, Mice, Bird." The nine pages of MS. containing them are missing [p. 381/209]. The author calls it fasciculus 3, and it is probably a continuation of C, which he called 2. From the opening paragraph it would appear that at first he did not accept the flints as human artifacts. He states: "Those from whom I have the misfortune to dissent on this subject are aware of my reserve and repugnance to admit their artificial origin" [p. 339/151]. So it is clear that when he found one on his first visit it was Buckland that determined its true nature. "From this period more especially—

March, 1827—I attached still greater importance to their presence, carefully, cautiously and deliberately scrutinised and noted their localities, and looked for fixed and settled grounds for building my opinion upon—but this evidence is not perhaps yet complete" [p. 339/151]. March, 1827, was the probable date of Buckland's first visit to Mac Enery after the Continental tour. The palaeontology is very good indeed, and furnishes evidence of his wide research.

Each genus is described separately and numbers of bones found are sometimes given, but these are often unreliable and only approximate. In one case he gives a list of the various rhinoceros teeth with the numbers found. The total is 404, but Mac Enery makes it "over 1,800." Pengelly rightly states: "there is some error in these numbers" [p. 356/184]. Under the heading *Ursus cultridens* Mac Enery gives a very full account and the only one that has come down to us, and he states that five canines "were found" and that "I have lately discovered in the same bed an incisor" [pp. 368-73/196-201]. As might be expected from its nature there are forty-two references to the plates. There is little in this fasciculus that will enable one to fix even an approximate date. There is no mention of Schmerling, 1833, which there would have been if he had seen that work. Since Mac Enery gave a cast of the incisor to the Paris Museum in 1831, the probability is that the date is 1832.

Fasciculus E.

This is a fragment, and as published by Pengelly is of composite origin. The first part paged in the MS., 1-39, and occupying eleven pages of printed matter, deals with elephants, hyaenas and wolves. It thus covers part of fasciculus D. There is not much palaeontology, but deals with the recent animals and is supplementary. The second part Pengelly states: "The following account of the Glires and of the Nuts is copied from a loose leaf written on both sides, but not paged. From the size and quality of the paper it probably belonged to this fasciculus [p. 393/221 note]. There is no clue to the date and no reference to the plates. All one can say is, "There it is."

Fasciculus F.

This has neither pagination nor index, and consists of twenty-eight pages of MS. and twenty-one of printed text.

It deals solely with mammals recent and fossil, and covers some of the ground of D and E, but is much fuller. Elephants, Deer and Bear are discussed, the last being incomplete with only casual reference to *cultridens*. Wolf, Fox, Cat, Weasel and Glutton receive slight attention. Under the heading "Distinction between Irish Elk and Cavern" there are two references to the plates. There is no clue as to the date. F may possibly represent an attempt to rewrite D.

Fasciculus G.

In the MS. this is paged from 1 to 60, but forty-six pages are missing, and so it only occupies nineteen pages of print. It is palaeontological. Mac Enery has one heading, "Comparison of Numbers between Kirkdale and Kent's Cave," but alas, in the list those from Kirkdale are given and there is no list from Kent's Hole. The first heading is "Genera and species of animals discovered in Kent's Cave." These are :

Pachydermata.
- 1. Elephant Asiatic.
- 2. Rhinoceros Bicorn [doubtful as to species].
- 3. Horse.
- 4. Ox.

Ruminantia.
- 5. Elk, Irish.
  - Red Deer.
  - Stag.
  - Fallow Deer, etc.
  - Reindeer.

Carnivora.
- 6. 4 sp. Bear *Ursus cultridens.*
  - *U. spaeleus* —.
  - *U. arctoideus*—.
  - *U. priscus.*
- 7. Hyaena stri.

The lower half of the leaf is missing. Some of the mammals in the above list are discussed as well as *Lagomys*, which was probably in the destroyed portion. The author states under "Feline" [i.e. Lion] "the scarcity of the bones of the Feline is not a little remarkable. The total amounts only to one upper jaw—about half a dozen canines and about the same number of molars" [p. 420 248]. In fasciculus D it is stated : "There have been found a dozen canines —and about half the number of molars and also a fine upper jaw." [379/207]. One might infer from the difference that G was earlier than D and in the interval more specimens had been found, but on May 3rd, 1826, when he sent the specimens to York, he stated that he had "large jaw, some fragments numerous teeth and tusks," whilst Trevelyan notes that Mrs. Cazalet had twelve lions' teeth on Feb. 27th, 1826, and she had previously given four to the Geological Society. Apparently Mac Enery kept no record of the number of specimens found and relied on his memory. There are only two references to the plates. The paragraph relating to Mastodon [p. 425/253] is possibly explained by the fact that Mac Enery, early in the dig, thought that some of the teeth might be Mastodon, for in the list noted above he cites "Mastodon Teeth supposed to belong to that animal." It is probable that Fasciculus G is an early version.

Fasciculus H.

This is a fragment. Pengelly states: "As this Fasciculus has neither pagination nor Index its original extent cannot be determined. Four pages at least appear to have been torn off" [p. 429/257]. It contains imperfect accounts of the geology of the district and the cave. The author states that he attended Mr. de la Beche "in his survey of this district" [p. 432/260], and there is also a reference to Northmore clearing one entrance [p. 434/262]. This clearing is also noted in fasciculus B [p. 264/76], so it is possible that H is an earlier version of B. From its nature there are no references to plates. There is no clue as to its date.

Fasciculus I.

Of this Pengelly states : " This Fasciculus has neither pagination nor Index. No part of it, however, appears to be missing " [p. 435/263]. . It occupies four pages of print and deals with the flints and the traditional early history of mankind. One passage must be quoted. " From the total absence of every relic of metal in the Diluvium and the great abundance of weapons of flint we may conclude at least that they had not yet discovered its existence in Britain, if they were not entirely ignorant of its properties and its subserviency to the arts of life. A nomadic people, strangers to even the rude pottery of a later period, most probably were also strangers to the use existence and application of the hard metals, which in after ages their descendants learned from the enterprising people of Phenicia " p. [437/265]. This shows that Mac Enery was far ahead of his times, for he had discriminated between the " Neolithic " with pottery and the " Palaeolithic " without. There is no plate reference and no clue as to when it was written.

Fasciculus J.

This consists of seventy-two " Scraps, Notes and Memoranda " which Pengelly has put together in his last fasciculus, and it furnishes most important evidence though some of them have but a remote affinity to the subject matter of the unborn book.

They occupy forty-four pages of print. Nos. 1 and 2 are two variants of the dedication to Sir Lawrence U. Palk, the owner of Kent's Hole [p. 439/267]. No. 4 is headed " Preface," and though incomplete may well have been intended for that purpose [p. 440/268]. No. 5 is also headed " Preface " and may have been part, but it furnishes most valuable evidence and has been overlooked. It begins, " In the summer of 1825 Dr. Buckland accompanied by Mr. Northmore of Cleve visited the cave of Kent's Hole in search of bones—I attended them. Nothing remarkable was discovered that day, excepting the tooth of a Rhin. and a flint blade. This was the first instance of the occurrence of British relics being noticed in this or, I believe, in any other cave ; both these relics twas my good fortune to find, but it was not the first case of the discovery of organic remains. Mr. W. C. Trevelyan of Wallington had but recently dug out subjects of sufficient number and interest to form a plate, and I am assured that at a still earlier period Mr. N. had collected some single teeth of Hyaena. To this ardent inquirer therefore the priority of discovery belongs—I should not omit to mention Col. Henderson, who casually alighted on similar bones while surveying the cave. Dr. Buckland had also on two former occasions made a search there, but owing to the want of leisure for pushing his inquiries nothing new was developed." " A few months after my first visit I resumed my researches, assisted by Mr. Northmore. On this occasion also I succeeded in bringing to light several interesting relics. They served as materials for a plate arranged by Dr. Buckland" [p. 441/269]. This is a totally different account from that of his "first" visit in fasciculus A [p. 208/20] and is, I think, the correct one. It also shows that Buckland did not inform Mac Enery of his previous find of a flint artifact [see p. 185].

No. 6. This has no heading, but is a condensed version of No. 5, but he does not mention Col. Henderson and states: "I resumed my researches in October of the same year" instead of "a few months after" [p. 443/271]. The plate states, "found in October, 1825"; so this date is fixed. I have been unable to trace Col. Henderson.

No. 10. Under the heading "Modern remains—Bones ornament—Hum. bones," he states: "In a pit in the stalagmite on the left of the excavation were discovered some Human bones reduced to carbon—a quantity of shells and a curiously formed ornament made of bone in form resembling a spear head—fig. —" [p. 446/274]. This plate is missing.

No. 16. Under the heading "*Accident*" he gives a short account of the incident [p. 451/279] and this scrap may precede Fasciculus C, [p. 301/p. 113]. A combination of the two is in Fasciculus A [p. 233/45].

No. 28. This is headed "Flints" and Pengelly states: "Apparently a list showing the number and distribution of the Flint knives found in the cavern [p. 458/286 note]. The lists is as follows :—

	36
Buck	1
Geol. S.	2
Mrs. C —	6
Mrs. D.	2
Mr. B.	2
Mr. Wel	3
Fam.	1
W —	1
Char —	3
Brah —	1
24	
36	
60	

The addition is certainly wrong. The figures 36 probably mean those in Mac Enery's possession Buck. is Buckland, Geol. S. explains itself, Mrs. C. is probably Mrs. Cazalet, Mr. B. may be the Rev. L. Belfield, Mr. Wel is probably the Revd. Lawrence Welland, and Brah is Mr. Braham.

The items may be incorrect: two certainly are. He credits the Geological Society with two and Mrs. Cazalet with six, but Mrs. Cazalet gave nine figured specimens to the Society and still had some left. This list has been overlooked by Prof. D. A. C. Garrod [75].

No. 32. In this Mac Enery states : " Between the flints found in the barrows in Wiltshire and those collected from the caverns of Kent's Hole, Anstis Cove and Berryhead, there is a singular identity both of material and form. Excepting that the barrow specimens have a more polished edge apparently from friction on a flag, but exhibit no other evidence of superior art. None of the cavern blades appear to have been rubbed or polished, but exhibit the rough serrated edge of the original fracture—this difference alone may not be sufficient to authorise us in assigning to the cavern reliques a higher antiquity—but the absence of other Druidical remains at the depth where the flint abound is a negative confirmation." [p. 461/289]. Here Mac Enery anticipated the division into Palaeolithic and Neolithic.

No. 68. Under Sus-Hog. it is stated "2 other fragments of jaws had been discovered by Dr. Buckland and the Rev. L. P. Welland—both much inferior in size—Dr. B. specimen is fig. in the plate of the Deer's remains" [p. 480/308].

Lastly, in No. 17, under the heading of "Superior Division," it is stated, "—next were developed works of art—viz. circular pieces of slate or beads—a quantity of broken pottery of the culinary and ornamental kinds—lumps of virgin ore—the particular description of [which] is reserved for a more detailed consideration of antiquities in [another] place" [p. 452/280]. The two words in square brackets are Pengelly's restorations for "part of the leaf is torn off here," but the sense is obvious. This shows that Mac Enery intended to write a full account of the more recent antiquities he had found. Fasciculus I may possibly be part of such an attempt. The fragments printed in Fasciculus J show clearly the wide extent of Mac Enery's reading and knowledge, and how far ahead he was of contemporary opinion.

Conclusions.

It is clear from the MS. that Mac Enery intended to divide his *Cavern Researches* into at least two parts. The first was to contain introductory matter such as the geology of the district, a description of the Cave and previous work there and a full account of his own work. The second part was to be palaeontological with a full description of the various species found, their presence in other deposits and if living their present habits and their osteology with the necessary deductions. It is probable, judging from what he said, that he intended to write a separate section dealing with the numerous human artifacts that he had found [p. 452/280]. This was a very ambitious object and I rather fear that he found it beyond his powers to keep pace with the ever increasing knowledge and work, and that this was the real cause of the failure to finish the work. Fasciculi A, B, C and H belong to his first part. A is probably 1837 from the references and is the most complete, but judging from the mutilation Mac Enery was not satisfied with it and since he died Feb. 18th, 1841, he may well have been working on it till nearly the end. B is probably 1829 and is an earlier version of part of A. G is later than B and may be dated 1831. H is a mere fragment of his first part without any clue as to its date. Fasciculi D, E, F. G and I belong to his second part, the palaeontological, and not one is so recent as A.

D may be a continuation of C and may be dated 1832 at the latest. There is no mention of Schmerling (1833), which there would certainly have been had he seen it and he had seen it when he wrote A. E may be supplementary to D and written soon after. F may be an attempt to rewrite D, but here also there is no mention of Schmerling. G is, I think, the earliest attempt at his second part, but it has been so badly mutilated that it furnishes no clue as to date. I is a fragment dealing only with flints without a clue, whilst J is of many dates, some certainly early and some possibly late.

IV. CAVERN RESEARCHES

This was to be the title of Mac Enery's projected work. An undated prospectus was issued on which it was described as " Shortly will be published, in one volume quarto, /Cavern Researches ;/ or, / Discoveries of Organic Remains / and / of British and Roman Reliques, / in the Caves of Kent's Hole, Anstis' Cave, Chudleigh and Berryhead ; / illustrated with Plates, / Representing the subjects of the natural size by Scharf ; including Views, Sections, and/Ground Plans of the principal Caves / by the Rev. J. Mac Enery, F.G.S. / Hon. mem. of the Yorkshire, Bristol, etc., etc., Phil. S.S. / In consequence of the great accession of specimens of the various remains above / enumerated, / and a desire not to exclude any, that may conduce to a complete history of / these abodes of successive generations of beings from the earliest period, it has been / found necessary to extend the plates to thirty. The limited circulation of / works of this nature, being by no means equal to the expenses attendant on the execu/tion of so large a series, the author is obliged to depart from his original plan, and to / solicit the support of those who may feel an interest in the result of his researches./ Subscriptions received at Cole's Library, Torquay, where specimens of the plates may be seen." Northmore in 1832 said it was issued about five years previous (Appendix).

The plates were drawn between May, 1827, and March, 1828, so that it is possible that the prospectus was issued late in 1827, but the date may well be 1828. The prospectus was reprinted by Pengelly [**31**, p, 198/10] and was copied in part by Vivian as the title page for his partial printing of Mac Enery's MS. under the same title [**22**]. The wording of the prospectus is explained by other evidence. At quite an early stage in his work—June 19th, 1826—Mac Enery wrote : "Some plain account I intend to publish," and on December 6th, 1826, Dr. Beeke wrote : " He [i.e. Mac Enery] has prepared the materials for an account of the Cave so far as his own observations extend." Up to this time it would appear that the work was to be a modest one, but in March, 1827, Buckland visited Mac Enery and recognised the importance of his discoveries, so a joint enterprise was arranged for the drawing of eighteen plates to be used for two works, Mac Enery's and the second volume of *Reliquiae Diluvianae*. Mac Enery had told his friends previously what he intended to do and the prospectus is an explanation of his changed intentions. De la Beche, in his paper read November, 1827, states : " The Rev. John McEnery who has formed a very valuable collection of these remains intends I believe to publish an account of them and Prof. Buckland will probably do the same in the continuation of his *Reliquiae Diluvianae* [**5**, p. 170]. Since Mac Enery accompanied de la Beche in his survey of the district this is probably a verbal communication from Mac Enery. Mac Enery was determined to do the work thoroughly and the references in his MS. show how wide his reading was, all branches of Science as well as the classics being quoted. It would appear that he was working on the subject to the very last. Probably the first complete draft was written before 1833, but the appearance of Schmerling's work on the Belgian Caves in that year upset matters and Mac Enery started rewriting his MS., probably in 1837, but he only finished part., i.e. Fasciculus A, and he was not satisfied with this, for it has alterations and had parts torn out. It is clear he was an extremely cautious man and wished to prove all his views. He was constitutionally averse to differ from " Authorities." The local enthusiasm which had hailed his early work had died out, so it is no wonder the book was never finished. Mac Enery died in 1841 and the history of the MS. after that date is given elsewhere. Early in 1859 Vivian published the book known as *Cavern Researches*. This is a compilation from the MS., the greater part being derived from Fasciculus A, the whole being rearranged to make it a consecutive story.

From the many omissions and needless alterations it is decidedly misleading, but one must not forget that we owe a great debt to Vivian for issuing the plates. If it had not been for Vivian these plates would only have been known by a few " pulls " and Scharf's bill. The later printing by Pengelly of the whole of the MS. removed all the wrong impressions caused by Vivian, though I am afraid that the latter's work is more often consulted than Pengelly's.

THE PLATES.

The prospectus of *Cavern Researches* states that there were to be thirty plates, but how many were drawn one cannot say. Scharf's bill is for eighteen and copies of all are known, sixteen having been published by Vivian [**16**]. In addition Plate F of *Machairodus* canines was certainly one, whilst there are references in Mac Enery's MS. to several unknown plates. Certain it is that proofs were distributed by Mac Enery and Buckland and were copied by later writers, with acknowledgment as by de Blainville [**9**], or without, as by Owen [**15**], but since all the figures are reversed, as first noted by Blake and Sherborn [**61**, p. 23], this point is easily settled. It is curious that Owen overlooked this reversal. Buckland sent proofs to Owen and the latter states : " M. de Blainville frequently cites a ' Description of the Cavern of Kent's Hole, Devonshire,' which he supposes to have been published by Mr. Mac Enery, but which he regrets that he had not been able to procure. I have been assured by Dr. Buckland that Mr. Mac Enery never published such a work ; and it is most probable that the drawings, or lithographic impressions, shown by Mr. Mac Enery to Professor de Blainville were those designed to illustrate the forthcoming second volume of the *Reliquiae Diluvianae* " [**15**, p. 166 note]. This was published in 1844, three years after Mac Enery's death, but on the face of it it would appear that Buckland did not inform Owen of all the facts.

Vivian quotes Owen's statement and adds: " Of the plates above referred to, sixteen were executed at the expense of the late lamented Dean of Westminster and by the liberality of his son, F. Buckland. Esq. (2nd Life Guards) I have been permitted to have some proof impressions taken to illustrate large paper copies " [i.e. quarto] [**22**, preface]. This information must have been given by Frank Buckland and he had certainly not studied Scharf's bill (Appendix), for that was made out to Buckland and Mac Enery and records a payment of £10 by Mr. Phillips (Dr. Lovell Phillips), which must have been made on behalf of Mac Enery. It is possible that Buckland paid the balance of the account, but even then it should have been " partly at the expense." Dawkins and Sanford in 1868 stated that the plates had a dual purpose, to illustrate Mac Enery's work and the second volume of *Reliquiae Diluvianae* and said the stones had been lost [**28**, p. 186], whilst Pengelly also maintained their dual purpose, pointing out that the plate letters and numbers agreed with those quoted in Mac Enery's MS. Had he known of Scharf's bill he would have been more emphatic in his conclusions [**31**, pp. 200/12—201/13]. The history of the plates is probably as follows.

Mac Enery at first intended to write an account of his work only, and it was probably nearly ready by the end of 1826.

In March, 1827, Buckland visited Torquay and recognised the importance of the finds and an agreement was made for eighteen plates to be drawn by Scharf, for the dual purpose. These were drawn between May, 1827, and March, 1828. Mac Enery deferred to Buckland in nearly everything, so it is probable that Buckland selected the specimens to be drawn and they were sent to London for that purpose. Buckland must have known of Mrs. Cazalet's donation to the Geological Society and this was utilised, for two plates and the figure of the human vertebra. The stones were sent to Buckland, who sent proofs to Mac Enery. By a lucky chance sixteen of the stones survived and were used by Vivian in 1859, and these disappeared before 1868.

The plates have never been explained, apart from the legends, though it is clear that an explanation was planned, and this I have tried to supply as well as the whereabouts of the various originals. In addition Mac Enery's references in his MS. are also given. Bibliographical details are also given as to other figures of these and other specimens found by Mac Enery, but text books and popular works are not included. The canines of *Machairodus* had such an appeal to popular fancy that they have been reproduced in nearly all such works.

Owing to the conditions it is probable that there are omissions and for these I crave your indulgence.

PLATE B.

LEGEND.—" Scull and underjaws of Hyaenas found in Kent's Hole, Torquay, by the Revd. J. Mc Enery, Natl. size. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel."

FIG. 1.—A skull and a fragmentary lower ramus. The skull is in the Torquay Museum, the ramus is missing. The skull was copied by Owen [**15**, p. 138, Fig. 54).

FIG. 2.—An imperfect mandibular ramus and is in the British Museum (Nat. Hist.,) No. 14173, but not noted by Lydekker [**53**]. Information kindly given by Dr. A. T. Hopwood. The figure has been copied by Owen [**15**, p. 157, Fig. 60).

Mac Enery's references, **31**, p. 286/98, 373/201, 374/202 as Plate 1, 376/204 as Plate 2.

A joint plate drawn May, 1827.

These specimens at that time were in the possession of Mac Enery.

This skull is mentioned in a letter from the Rev. Dr. Beeke, Dean of Bristol, to W. C. Trevelyan dated Dec. 6, 1826.

PLATE C.

LEGEND.—" 1. Upper jaw of a large Tiger, in the possession of Sir Lawrence Palk, Bart. 2. Irregular tusk of Bear. 3. Irregular underjaw of Hyaena found in Kent's Hole, Torquay, by the Revd. J. Mc Enery lithographed from Nature by G. Scharf, nat. size. Printed by C. Hullmandel."

FIG. 1.—In British Museum (Nat. Hist.) No. 17921, purchased at the Mac Enery Sale 1842. A cast in the Geological Survey Museum (G.S. 111 *ex* Coll. Geol. Soc.) given by Mrs. Cazalet, May 6th, 1827. This gives a clue as to the date of discovery. Mac Enery states that Sir Lawrence Palk possessed a good series [**31**, p. 250/62). He was the owner of Kent's Hole, and one can only assume that his specimens were given back to Mac Enery later.

FIG. 1.—Figured from the original by Owen [**15**, p. 161, Fig. 63], described by Dawkins and Sanford [**28**, p. 31] and by Lydekker in 1885 [**53**, vol. i, p. 50]. who overlooked the fact that it had been figured by Mac Enery. It would appear that when Lydekker wrote his first volume he was not aware of the existence of these plates, for it was not until vol. ii that he noted them.

FIG. 2.—Abnormal canine of *Ursus*. Not known, but may be in the British Museum (Nat. Hist.). There are two canines cited by Lydekker, Nos. 725 and 18277 *ex* Mac Enery's Sale [**53**, vol. i., p. 164], but they are not available for comparison.

FIG. 3.—Abnormal mandibular rami of Hyaena as drawn by Scharf. This comprises the right and left mandibular rami. The right ramus is in the British Museum (Nat. Hist.), No. 15436. Lydekker describes it as " Anterior portion of right ramus of the mandible showing the canine and the three premolars, Kent's Hole. In this specimen pm 3 is double, there being one tooth in the regular line (which is much more worn than the teeth in front and behind), and a second tooth on the outer side of the regular line which is in the same state of wear as the teeth in front and behind ; the large size of the much worn tooth proves that it cannot be a retained milk molar " [**53**, vol. i, p. 74]. The letters A, B, C, D on the plate have never been explained. A and B are the two abnormal teeth. C and D may be " gnawed by Hyaenas." The left ramus is missing.

Mac Enery's reference, **31**, p. 379/207. " Feline upper jaw, Fig. 1."

A joint plate drawn August, 1827, three months after the cast was given by Mrs. Cazalet to the Geological Society.

All these specimens except Fig. i. were probably in Mac Enery's possession when drawn.

PLATE D.

LEGEND.—" 1. Under jaw of fossil Bear (*Ursus arctoideus*). 2. Under jaw of *Ursus spelaeus*, both found in Kent's Hole, Torquay, by the Rev. L. P. Welland. Lithographed from Nature by G. Scharf. Nat. size. Printed by C. Hulmandel."

FIGS 3-6 are not noticed, but are detached teeth of *Ursus*. Mac Enery states: " The Revd. Lawrence Welland, a near relation of Sir L. Palk, likewise pursued investigations in this cavern and with extraordinary success. The lip of the Gigantic Bear (Fig. P) was discovered in the cave of Inscriptions by Mr. Welland—I have compared it with the fossil jaws of the Bear from the caverns of Germany in the collections of Paris, etc., and have found none to equal it in volume. It must have belonged to an individual of prodigious size not inferior to the largest Buffalo—or Ox.

" Mr. Welland also was fortunate in making other discoveries sufficient to form a curious collection of the Fossil R[emains] from this cavern " [**31**, p. 250/62]. The use of the trivial name *arctoideus* is interesting. It is of Goldfuss 1810 and it is doubtful if anyone in England could have named it in 1827, and it may well have been named by Cuvier [see **31**, p. 368/196].

All the originals are missing, but those of Figs. 3-6 may well have belonged to Mac Enery.

MAC ENERY'S REFERENCES.—Besides the above cited reference see **31**, p. 304/116, p. 418/246. On p. 367/195 Mac Enery states : " Gigantic Bear of this cavern is distinguished by the presence of an anterior molar at the base of the canine as marked ' a ' Fig.—plate." Pengelly notes : " The author here refers to Fig. 1 Plate D Cavern Researches. The 'a' does not occur in the published plate, but a copy of it containing the ' a ' inserted in pencil by Mr. Mac Enery has recently (June, 1869) been presented to the Torquay Natural History Society by Mr. Gardner, Torquay." This is a good example of the meticulous care with which Pengelly edited the MS. Since fasciculus D cannot have been written before 1832 it shows that Mac Enery was still endeavouring to improve his plates.

A joint plate drawn August, 1827.

PLATE E.

LEGEND.—" 12. Canine teeth of Tiger, 3, 4 of Bear (*Ursus spelaeus*), 5, 6, 7 molars of Tiger, 8, 9 under jaws of Rabbit and Hare, 10, 11 head of Lagomus, 12, underjaw of Bat, 13 of Badger, 14 of Fox, 15,16 Field Mice, 17 head of Weasel, 18 under jaw of Cat found in Kent's Hole by the Revd. J. Mc Enery. G. Scharf lithog. from Nature. Nat. size. Printed by C. Hullmandel."

FIGS. 1-7, originals not traced ; 5, 6 and 7 copied by de Blainville [**9**, Felis pl. xv. and xvi, Fig. 2.] Fig. 8 not traced. It is not No. 15089 British Museum (Nat. Hist.) figured by Owen from the original in the same Museum [**15**, p. 210, Fig. 80]. Figs 10 and 11, original in British Museum (Nat. Hist.) No. 48886, figured by Owen from the original [**15**, p. 213, Figs. 82-4]. This is the type of *Lagomys spelaeus* Owen. Whether *Lagomus* is an error for or an emendation of *Lagomys* one cannot say but the generic name is proposed. The identification may have been made by Cuvier in 1826 when Buckland visited him. Fig. 12, the original may be in the British Museum (Nat. Hist.) amongst Nos. 15082-92, " Bat remains from the Mac Enery Coll." and noted by Owen [**15**, p. 16]. Fig. 13, Ramus of Badger. Original in British Museum (Nat. Hist.). No. 16711, figured by Owen from the original [**15**, p. 109, Fig. 37), noted by de Blainville [**9**, Subursus, p. 47]. Figs. 14-16 not traced. Fig. 17, head of Weasel, original in British Museum (Nat. Hist.). No. 16709, figured by Owen from the original [**15**, p. 118, Fig. 42], noted by de Blainville [9 Subursus, p. 59], figured by Reynolds [**66**, pl. II, Fig. 9]. Fig. 18, Ramus of Cat, original in British Museum (Nat. Hist.). No. 16710, copied by de Blainville [9 Felis pl. xvi]. Lydekker describes it as " the left ramus of the mandible Kent's Hole Cavern, Torquay " [**53**, vol. i, p. 64]. This specimen is mentioned by Owen [**15**, p. 173] and the teeth are figured in outline in the figure on the preceding page. This figure, No. 67, is said to be from Grays and is thus a composite figure of the ramus from Grays and the teeth in outline from Kent's Hole, and they are not of the same age. Mac Enery's references [**31**], Fig. 1, " inferior tooth " p. 309/207 ; Figs. 1 and 2,

" large and small canines, p. 422/250 ; Fig. 2, large canine, p. 379/207 ; Fig. 5, 6 and 7, feline molars, p. 379/207 ; Fig. 13, " under jaw of Badger, p. 261/73 and 381/209 ; Fig. 14, " under jaw of Fox, p. 255/67 ; Fig. 17, " head of Weasel," p. 380/208 ; Fig. 18, " under jaw larger than common Cat,"

A joint plate drawn September, 1827.

PLATE F.

LEGEND.—" Teeth of *Ursus cultridens*. Found in the cave of Kent's Hole, near Torquay, Devon, by Revd. Mr. Mc Enery Jany, 1826, in diluvial mud mixd with Teeth and gnaw'd bones of Rhinoceros, Elephant, Horse, Ox, Elk and Deer with teeth and bones of Hyaenas, Bears, Wolves, Foxes, etc. Mary Buckland del. Nat. size. G. Scharf Lithog." [no printer's name.] This plate was reproduced by Dawkins and Sanford [**28**, pl. XXV]. and like the originals the figures are reversed. The seven figures represent three specimens. Figs. 1, 2 and 3, in British Museum (Nat. Hist.), No. 14954. Figs. 4, 5 and 6, in Geological Survey Museum *ex* Geol. Soc. Coll. Mrs. Cazalet don. Feb. 17th, 1826. G.S. 422 (23413).

FIG. 7, in Geological Survey Museum No. 62957. Sir W. C. Trevelyan don. May 15th, 1871. A full account of these specimens is given later (see p. 188).

It is very difficult to place this plate for it differs from all the others. I think that its history is as follows : The canine teeth of *Machairodus* were found early in January, 1826. They were at once sent to Buckland. They were unknown to him, and though Mrs. Buckland no doubt was busy preparing for their honeymoon—for they had been married on December 31st,1825—she found time to make the drawings and the specimens were returned to Mac Enery at once, one may have been retained, for Mrs. Cazalet had two of the figured specimens before February 17th, 1826, for on that date she presented one to the Geological Society. When the Bucklands went on their honeymoon I cannot trace, but they were in Paris on February 25th [**55**, p. 92]. At the beginning of March they visited Cuvier, taking with them a parcel of remains from Kent's Hole, sent by Mac Enery, including one of the unfigured specimens. This was recognised by Cuvier as his *Ursus cultridens*. Buckland wrote to Mac Enery March 14th from Lyons, enclosing Cuvier's letter of thanks dated March 6th and giving Cuvier's determination. So the identity was not established until after March 14th. So far we are on safe ground, but the rest of the story is a deduction. Nothing more was done until after the return of the Bucklands at the end of 1826. Then Scharf was enlisted to draw the figures on stone, probably early in 1827, and the legend added, which is so different from all the others, and the plate was obviously not drawn for the same purpose as the others, i.e. to illustrate Buckland's and Mac Enery's projected volumes, though later on this use was intended. The plate was to be a record of what had been found, as was the custom of the time.

Mac Enery's references. *Ursus cultridens* [**31**, pp. 369/197, 457/285].

PLATE G.

LEGEND.—" Entire Head of a large Wolf found in Kent's Hole, Torquay, by the Revd. J. Mc Enery. Nat. size. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel." Copied by Owen [**15**, p. 123, Fig. 45]. Figured from the original by Reynolds [**66**, pt. iii, pl. 1], who states : " This specimen which was figured by Mac Enery and by Owen is preserved in the Torquay Museum. Since these authors figured the skull the mandible has been lost and the cranium somewhat damaged." (*Op. cit.*, explan. of plate). Owen merely copied Mac Enery's figure drawn June, 1827. The skull and mandible were probably in separate lots at the Mac Enery Sale, and no blame can be attached to the present custodians. All one can really say is that it has been damaged since June, 1827. The jaw has not been traced, but it may be No. 15636. British Museum (Nat. Hist.) [**53**, vol. i, p. 124]. Reynold's further statement " the plate was the frontispiece of *Cavern Researches* [66, expl. of Plate] is incorrect. It is not so in the two copies I have seen, which are in the original bindings, Mac Enery's references [**31**] " Head of the Wolf," pp. 243/55, 294/106, 375/203, " magnificent head," p. 380/208. Mac Enery was very proud of this skull and rightly so.

A joint plate drawn June, 1827.

PLATE H.

LEGEND.—“ 1. Horn of small Deer. 2. of Elk. 3. of Red Deer gnawed to their actual state by Hyaenas. Found in Kent's Hole by the Revd. J. Mc Enery. Natl. size.” Neither artist nor printer named, but Scharf is certainly the artist.

Fig. 1 is *Rangifer tarandus* (Linné) and is in the British Museum (Nat. Hist.), No. 16824, not noted by Lydekker [53]. Information kindly given by Dr. A. T. Hopwood. Fig. 2 not traced. Fig. 3 in British Museum (Nat. Hist.) No. 16820a, figured from the original by Owen [**15**, p. 469, Fig. 193] as *Strongyloceros spelaeus* Owen and is the type. Lydekker refers it to *Cervus elaphus* Linné and states : “ The base of the right antler with the brow and the lez tines broken off. It measures fifteen inches in circumference, and is equal in size to the largest antlers of *C. canadensis*, with which it is compared by Owen ” [**53**, vol. ii, p. 96).

Mac Enery's references [**31**] Fig. 1, “ round and slender horn ” 410/238, Fig. 3, “ a species allied to the Great Red Deer,” p. 363/191 [This anticipates Owen], p. 410/238, “ gnawed Horns ” p. 364/192.

A joint plate drawn June, 1827.

PLATE I.

LEGEND.—“ 1. Palate of large Elk reduced to this form by Hyaena. 2. Under jaw of Elk, found in Kent's Hole, Torquay, by the Rev. J. Mc Enery. Natl. size. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel.”

Fig. 1, in British Museum (Nat. Hist.), No. 17471, described by Lydekker as *Cervus giganteus* Blum. “ The palate showing all the teeth on both sides except p.m. 2 from Kent's Cavern [**53**, vol. ii, p. 85] noticed by Owen [**15**, p. 467]. Fig. 2, in Geological Survey Museum G.S. 388, *ex* Geol. Soc. Coll. W. Longdon. June 6th, 1847. This figure was copied by Owen as “ fragment of underjaw (*Strongyloceros spelaeus* ?) ” [**15**, p. 471, Fig. 195).

Mac Enery's references “ entire palate equalling in size the Irish Elk ” [**31**, p. 362/190, and on p. 287/99 “ Palates of Elk were extracted from this bed,” but no reference is given to the plate.

A joint plate. Fig. 1 was drawn June, 1827. Fig. 2 was added Nov., 1827. Query : Was the latter found between those dates ? There are marked differences between the drawings, whilst the artist's and printer's names are in very small characters.

PLATE K.

LEGEND.—“ 1. Jaw of a Hog. 2, 3, 4. of Deer. 5. of Ox. 6. of Horse, found in Kent's Hole by the Revd. J. Mc Enery. Natural size. Lithographed from Nature by G. Scharf, printed by C. Hullmandel.”

Fig. 1 not traced, but probably at Oxford, for it was found by Buckland. Fig. 2, in British Museum (Nat. Hist.), No. 16818, described by Lydekker as *Rangifer tarandus* (Linné). “ Fragment of the left ramus of the mandible of a young individual with the two milk molars and the firt lobe of m.1 [**53**, vol. ii, p. 81]. Fig. 3, in British Museum (Nat. Hist.) No. 16893, described by Lydekker as *Rangifer tarandus* (Linné). “ Part of the left ramus of the mandible with all the cheek teeth except p.m. 2 [53, vol. ii, p. 81]. Fig. 4, in British Museum (Nat. Hist.), No. 16820 b, described by Lydekker as *Cervus giganteus* Blum. “ The dental series of the left ramus of the mandible ” [**53**, vol. ii, p. 86], but on p. 98 referred with doubt to *Cervus elaphus* Linné and described as “ Part of the left ramus of the mandible of a very large individual containing all the cheek teeth except p.m. 2.” The specimen is not available for re-examination. Fig. 5, in British Museum (Nat. Hist.), No. 16800, described by Lydekker as *Cervus giganteus* Blum. “ Part of the left ramus of the mandible from Kent's Cavern ” [53, vol. ii, p. 86]. On the plate it is said to be Ox and Mac Enery in his MS. refers it to horse. Fig. 6, in British Museum (Nat. Hist.), No. 15637, described by Lydekker as *Equus caballus* Linné. “ Part of the right ramus of the mandible with the last five cheek teeth ” [53, vol. iii, p. 77].

Mac Enery's references [31, Fig. 1, “ Dr. Buckland's specimen [of *Sus-Hog*] is fig. in the Plate of the Deer's remains, p. 480 308, Figs. 5 and 6 Horse jaws gnawed by Hyaenas ”—*vid.* Pl. K, Figs. 5-6 ” p. 359/187. Fig. 5 is an error. Fig. 5 ? under jaw of Ox “ Vid. P. Fig —.” p. 361/189.

A joint plate drawn June, 1827.

PLATE L.

Legend.—" Teeth and bony Base of the Nose Horn of a Rhinoceros, gnawed round the Edges. Found in Kent's Hole, Torquay, by the Revd. J. Mc Enery. Lithographed from Nature by G. Scharf. Nat. size. Printed by C. Hullmandel."

Figs. 1-5 and 7-10 are teeth of *Rhinoceros antiquitatis* Blum. and have not been traced.

Fig. 6, in British Museum (Nat. Hist.), No. 14600, described by Lydekker as *Rhinoceros antiquitatis* Blum.

" The middle portion of the nasals gnawed by Hyaenas," [**53**, vol. iii, p. 94]. Mac Enery's references [**31**, Fig. 5] : " Three bony bases of the Horns of the Rhin—Fig. 6, Plate 2nd," p. 356/184. On the same and the preceding page is a list of Rhinoceros teeth from the cave classified by references to the figures. The figures must be incorrect. As they stand the total is 432, but Mac Enery makes it " Over 1800." Of the three " bony bases " there is another in the Geological Survey Museum—*ex* Coll. Geol. Soc. Mrs. Cazalet don. Feb. 17th, 1826.

A joint plate drawn July, 1827.

PLATE M.

Legend.—" 1. 2. 3. Teeth of young Elephant. 4.5. Teeth of young Rhinoceros. 6. Under jaw of a young Deer. 7. Under jaw of a young Bear. 8. 9. Under jaws of young Hyaenas found in Kent's Hole by the Revd. McEnery. Lithographed from Nature by G. Scharf. Nat. size. Printed by C. Hullmandel."

Fig. 1, in British Museum (Nat. Hist.), No. 15001. Lydekker refers it to *Elephas primigenius* Blum. " An almost unworn third lower milk molar " [**53**, vol. iv, p. 197], figured and described by Leith Adams [**46**, p. 92, Pl. xiii, Fig. 2]. Fig. 2, in British Museum (Nat. Hist.), No. 16814. Lydekker refers it to *E. primigenius*, " a partially worn third lower milk molar with the cement partially scaled off " [**53**, vol. iv, p. 197]. Fig. 3, in British Museum (Nat. Hist.), No. 15000. Lydekker identifies it as *E. primigenius*. " The third upper left milk molar " [**53**, vol. iv, p. 197]. Figs. 4 and 5 are teeth of *Rhinoceros antiquitatis* Blum. and have not been traced. Fig. 6, in British Museum (Nat. Hist.), No. 16808. Lydekker refers it to *Rangifer tarandus* (Linné) " Fragment of the left ramus of the mandible of a young individual with $\overline{\mathrm{m.m.4}}$ and $\overline{\mathrm{m.1}}$ in alveolo " [**53**, vol. ii, p. 81]. Fig. 7. There has been a muddle over this. The figure was copied by Owen and said to be a young *Ursus spelaeus* Rosen. and like the original was reversed. Lydekker claimed that No. 18307, in British Museum (Nat. Hist.) was the original. He states that this specimen was *Ursus spelaeus* Rosen, and described it as "Fragment of the right ramus of the mandible of a very young individual containing the second true molar. This specimen is figured by Owen in the Brit. Foss. Mam., Fig. 36, p. 108. In the figure the canine is shown which is now wanting " [**53**, vol. i, p. 163]. But the specimen figured by Mac Enery and copied by Owen is a left ramus for all Mac Enery's figures are reversed as first noted by Blake and Sherborn in 1902, a fact that Lydekker was unaware of. Hence it is clear that No. 18307 is not the original, and this may explain the supposed absence of the canine, whilst the original has not been traced.

Figs. 8 and 9 are lower jaws of *Hyaena spelaea* Gold. and have not been traced.

Mac Enery's references [**31**, Fig. 1] " a milk tooth which had not been quite formed. Only two of these unformed teeth have been found." Fig. 2, p. 352/164, Figs. 1, 2, 3, " represent the gradual progress of growth and wear in the milk set. Of this description about six specimens have been found," p. 352/164.

Fig. 7. " I possess the jaw of a very young Bear with its second set of teeth yet concealed in the gum," p. 366/194. Fig. 8. Jaws of Hyaena. " Even the most fragile jaws retain their milk teeth," p. 253/65, " mere membranous shells with their milk teeth still unused and standing and harbouring second series," p. 373/201 also p. 457/285. Fig. 9. " The entire under jaw or lip of the Hy—," p. 234/46.

A joint plate drawn July 1827.

PLATE N.

Legend.—" 1. Femur. 2. Ulna. 3. Radius. 4. Humerus. 5. Tibia of Bear. Kent's Hole, Torquay. Revd. J. McEnery. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel." [All figures are reduced one-half.]

Fig. 1. Femur of *Ursus spelaeus* Rosen., in Geological Survey Museum G. S. 389, *ex* Geol. Soc. Coll., W. Long don.

Fig. 2. Ulna of *U. spelaeus* Rosen. in Geological Survey Museum G.S. 390 *ex* Geol. Soc. Coll., W. Long don.

Fig. 3. Radius of *U. spelaeus* Rosen. in Geological Survey Museum, G.S. 391, *ex* Geol. Soc. Coll., W. Long don.

Figs. 4 and 5 not traced.

The originals of Figs. 1, 2 and 3 were given to the Society June 16th, 1847, and are *ex* Mac Enery Coll.

Mac Enery's reference [31] " it is singular that they have escaped almost entire from the fate which has befallen all the others Pl. N.," p. 366/194 [i.e., broken by Hyaenas].

A joint plate drawn March, 1828.

PLATE P.

Legend.—" 1, 4. Gnawed tibia. 2, 5. Femur. 3, 6. Osinnominatum of Rhinoceros, Kent's Hole, Torquay, scale ⅓. Nat. size. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel."

Figs. 1,2 3, and 4 not traced.

Fig. 5, in Geological Survey Museum, G.S. 392, *ex* Geol. Soc. Coll., W. Long don.

Fig. 6, in Geological Survey Museum, G.S. 393 *ex* Geol. Soc. Coll., W. Long don.

All the specimens are probably *Rhinoceros antiquitatis* Blum., the only species of this genus known from the cave.

Mac Enery's references [31] " Long bones were broken and gnawed, Pla. P., p. 247 59." Fig. 5 average state of the entire number. Those belonging to young individuals suffered most and were reduced to nearly shapeless stumps, Fig. 4." " Fig. 2 conveys a correct idea of all these bones," " channelled with the furrows of teeth resembling rough lines produced by a file—Pl. P., Fig. 6," p. 358/186. The originals of Figs. 5 and 6 were given to the Society June 16th, 1847, and are *ex* Mac Enery's Coll.

A joint plate drawn Jan., 1828.

PLATE Q.

Legend.—" 1, 2. Humerus. 3. Ulna. 4. Radius. 5. Scapula of Rhinoceros. 6. Metacarpus. 7. Radius. 8. Cuboid bone of Ox. 9. Metatarsus. 10, 11, 12. Phalanges of Horse. Kent's Hole, Torquay. Scale ⅓. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel."

Figs. 1, 2 and 3 not traced.

Fig. 4. In Geological Survey Museum, G.S. 394, *ex* Geol. Soc. Coll., W. Long don.

Fig. 5. In Geological Survey Museum G.S. 395 *ex* Geol. Soc. Coll., W. Long don.

Figs. 1-5 are probably *Rhinoceros antiquitatis* Blum.

Fig. 6. Fragmentary metacarpus of *Bos* or *Bison*, in Geological Survey Museum, G.S. 396, *ex* Geol. Soc. Coll., W. Long don.

Fig. 7 not traced.

Fig. 8. Cuboid of *Bos* or *Bison*, in Geological Survey Museum, G.S. 397 *ex* Geol. Soc. Coll., W. Long don.

Fig. 9. Metacarpal of *Equus* sp. in Geological Survey Museum, G.S. 398, *ex* Geol. Soc. Coll., W. Long don.

Fig. 10. Phalange of *Equus* sp., in Geological Survey Museum, G.S. 399, *ex* Geol. Soc. Coll., W. Long don.

Fig. 11. Phalange of *Equus* sp., in Geological Survey Museum, G.S. 400, *ex* Geol. Soc. Coll., W. Long don.

Fig. 12. Phalange of *Equus* sp. in Geological Survey Museum, G.S. 401, *ex* Geol. Soc. Coll., W. Long don..

All the traced specimens were given June 16th, 1847, and are *ex* Mac Enery Coll.

Mac Enery's references [31]. The extremities of the femora have been snapped off and consumed ; those parts being softest and most nutritious—and the process has been performed in so uniform a manner that in the fifty specimens before me there is no variation discoverable in the mode of operation. Pl. Q ;" "the least injured Pl.Q, Fig. 1." "Those which preserve their condyles are deeply lacerated and indented, Plate Q, Fig. 1." "The cubitus of the Rhin. have been chopped at their smaller end, Plate Q, Fig. 3," p. 327/185. "The radii which are commonly broken about half-way at their slenderest points—Pl. Q. F. 4," p. 358/186. "A hoof and footbones have been found and are fig.," "a small species of the Horse Genus" [Pl. Q, Figs. 9, 10, 11 and 12], p. 359/187. "The hoofs very little damaged by teeth tho there is sufficient to show that they glanced off from the hard substance—vid. Pl. Q, Figs. 9, 10, 11, 12. The same may be said of the solid bones of the Ox. Vid. Pl. [Q], 6, 7, 8," p. 361/189. "Long bones broken and gnawed," p. 247/59.

A joint plate drawn March, 1828.

PLATE R.

Legend.—"Bear's tooth and fragments of Bones all bearing marks of having been gnawed by the Teeth of Hyaenas, Kent's Hole, Torquay. Reduced one-third. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel."

Fig. 1. Gnawed fragment in Geological Survey Musuem, G.S. 402, *ex* Geol. Soc. Coll., W. Long don.

Fig. 2. Gnawed fragment in Geological Survey Museum, G.S. 403, *ex* Geol. Soc. Coll., W. Long don.

Fig. 3. Gnawed fragment in Geological Survey Museum, G.S. 404, *ex* Geol. Soc. Coll., W. Long don.

Figs. 4 and 5 not traced.

Fig. 6. Gnawed fragment in Geological Survey Museum, G.S. 405, *ex* Geol. Soc. Coll., W. Long don.

Fig. 7. Canine of *Ursus spelaeus* Rosen. in Geological Survey Museum, G.S. 408, *ex* Geol. Soc. Coll., W. Long don.

Fig. 8 not traced.

Fig. 9. Gnawed fragment in Geological Survey Museum, G.S. 406, *ex* Geol. Soc. Coll., W. Long don.

Fig. 10. Gnawed fragment in Geological Survey Museum, G.S. 407, *ex* Geol. Soc. Coll., W. Long don. All the traced examples were given June 16th, 1847, and are *ex* Mac Enery's Coll.

Mac Enery's references [31]. "Long bones broken and gnawed," p. 247/59. "The animal resorted to chipping off morsel after morsel from the truncated ends and finally smoothing and fining off the rugged points—Pl. R., Fig. 6," p. 357/185. "A dozen tibia of the Horse have been collected all similarly broken as that fig. 1 Pl. R," p. 360/188. "The tusks [i.e., canines of Bear] which with the single teeth remained after the destruction of the jaws are ganwed at the base of their fangs and present the curious marks of the collision of the opposite canines of the Hyaenas jaws as may be seen in Fig. 7, Plate R.," p. 366 194. "The rest are broken like those of the horse and deer—in the manner of those fig.— Pl. R," p. 362/190. "Their inferior size rendered them easy food and consequently we find only small splinters comminuted and chippings which fell from the mouth or were refused as sapless—*Vid.* Pl., R. Fig. 4," p. 374/202. "Second gnawing. The inside concave surface displays holes produced by pressure against the conical teeth of u[pper] j[aw] while it held the bones and served as a species of fulcrum during the terrible operation *vide* Plat R," Figs. 4, 9, 10. When placed between the jaws the teeth are found to fall into the furrows and precisely similar impressions have been produced by closing the jaws on a soft paste," p. 375/203. [This experiment shows how thoroughly Mac Enery did his work.]

A joint plate drawn Jan., 1828.

PLATE S.

Legend.—" 1, 2, 3. *Album graecum.* 4,5. Broken and diseased Radius of Bear. 6. Exostosis on vertebra of a Bear. 7. Recent Human vertebra, from Kent's Hole, Torquay. Natl. size. Lithographed from Nature by G. Scharf. Printed by C. Hullmandel."

Figs. 1 and 2 not traced.

Fig. 3. Coprolite of Hyaena, Geological Survey Museum, G.S. 409, *ex* Geol. Soc. Coll., W. Long don.

Figs. 4 and 5. A broken and diseased radius of *Ursus spelaeus* Rosen., Geological Survey Museum, G.S. 410, *ex* Geol. Soc. Coll., W. Long don. Fig. 5 was copied by Owen [**15**, p. 104, Fig. 34] for his figure is reversed.

Fig. 6. A diseased vertebra of *Ursus spelaeus* Rosen., Geological Survey Museum, G.S. 411, *ex* Geol. Soc. Coll., W. Long don.

Fig. 7. A vertebra of *Homo sapiens* Linné, Geological Survey Museum, G.S. 412, (23427) *ex* Geol. Soc. Coll., Mrs. Cazalet don. Feb. 17th, 1826. Mr. Long's specimens were given June 16th, 1847.

The statement that the human vertebra is " recent " is borne out by its condition, which is quite different from that of the other bones.

Mac Enery's reference [**31**]. " With the exception of single teeth and an occasional rib or vetebra in the charcoal which may have possibly belonged to the same subject. There were no other traces of Human remains (*vid.* H[uman] Vertae Pl. —)," p. 223/35.

A joint plate drawn Jan. 1 828.

All the originals were in the Mac Enery Coll. at that date except that of Fig. 7. which was in London, so that this figure must have been drawn in London.

PLATE T.

Legend.—" Knives, arrow heads and hatchets of flint and chert, found in Kent's Hole, Torquay, by the Revd. J. Mc Enery. Natl. size. Printed by C. Hullmandel." These are all of late Palaeolithic age and represent nine specimens. All are in the Geological Survey Museum *ex* Geol. Soc. Coll., Mrs. Cazalet don., Feb. 17th, 1826.

Figs. 1 and 2 = G.S. 413.
Figs. 3 and 4 = G.S. 415.
Fig. 5 = G.S. 414.
Figs. 6 and 7 = G.S. 416.
Figs. 8 and 9 = G.S. 417.
Fig. 10 = G.S. 418.
Fig. 11 = G.S. 419.
Fig. 12 = G.S. 420.
Fig. 13 = G.S. 421.

Mac Enery's references [**31**, Plate T] " representing arrow and spearheads and hatchets," p. 221/33. " The result of my examination of an area of square yards was one flint in the disturbed bed—and the spear head (fig. —) and few knives in the virgin loam," p. 336/148. " Some of the flint blocks were chipped only on one side such as had probably furnished the axes, (fig. —). Others had been on several faces corresponding exactly to the long blades fig. found by their side (and fig. —) and from which they had evidently been sliced off," p. 221/33.

A joint plate drawn Dec., 1827, and since the originals were then in the Coll. Geol. Soc. the plate must have been drawn in London.

There are two plates recorded on G. Scharf's bill which were not published by Vivian, and one can presume that the stones had been lost. Copies of both are known.

Pengelley states " During the present year (1869) a series of plates obtained through one of the executors of the late Mr. Mac Enery was presented to the Torquay Natural History Society by Messrs. Gardner and Greenfield of Torquay. Many of them are copies of those just described [Vivian's plates], but with them are two new ones apparently belonging to the same set. They are defined as Plates O and U, the latter a continuation of the series and the former filling a hiatus in it " (p. 200/12).

" O contains twenty-one figures of remains of animals found in Kent's Hole, Torquay." " Lithographed from Nature by G. Scharf," p. 200/12. It is described by Scharf as " Bones—toes of bear, Hyaena, etc." (see Appendix, p. —) and was drawn Dec., 1827. From this description it is certainly the missing plate noted by Blake and Sherborn [**61**] from the artist's numbers in pencil on eight bones given by Mrs. Cazalet to the Geol. Soc. of London Feb. 17th, 1826, and now in the Geological Survey Museum, Nos. G.S. 423-430.

"U contains seventeen figures of Knives and Arrowheads of flint and obsidian from Stonehenge and Mexico with splinters of flint produced in modern process of making gun flints. Collected by the Revd. Dr. Buckland. Nat. size. Lithographed from Nature by G. Scharf" [**31**, p. 200/12]. Mac Enery's reference to the plate : "Institute a comparison with those found in Mexico and Barrows," p. 222/34. [A reminder by Mac Enery to elaborate this part of the MS.]

The originals are probably at Oxford. The late Sir Arthur Smith Woodward informed me that there is a copy of this plate in the British Museum (Nat.Hist.) in the "Owen" MS.

There are one drawing and two other plates known of bones from Kent's Hole.

1. Mac Enery states "In addition to the canines [*Machairodus*] I have lately discovered in the same bed a small tooth about an inch long—the internal face of the enamel is fringed with a serrated border." He then gives a full description of it. "*vid.* Fig. 8, 9" and is undecided whether it is a small species of *Ursus cultridens* or an incisor of that species [**31**, p. 370/198]. In a footnote to this Pengelly says there is a plate in the Torquay Museum "containing five figures of which three are without doubt different views of the tooth described by the author. Besides the figures there is nothing in the Plate except the words 'I. Scharf del. 1837'." If the drawings were the figures referred to by Mac Enery it would imply that he was digging as late as 1837.

Later Pengelly states that this is not a lithograph but drawings [**39**, p. 173]. These are discussed under *Machairodus*.

2. MAC ENERY'S FIRST PLATE.

Mac Enery has given a full account of the origin and drawing of this [**31**, pp. 208/20—210/22]. Copies of it are known and Pengelly states that it bears the legend "Teeth and Bones found in Kent's Hole near Torquay, Devon, by the Rev. I. Mc Enery in October, 1825. Drawn on stone by M. Morland" [**31**, p. 210/22 note]. This fixes the date of the dig and shows that the plate was drawn before Dec. 31st, 1825, when Miss Morland was married. Mac Enery has two other references to the plate [**31**, p. 269/441 and p. 271/443]. These are two earlier variants. When this plate was drawn Mac Enery had no intention of publishing, but it is possible that later he intended it to be Pl. A and one of the thirty promised.

3. TREVELYAN'S PLATE.

Sir W. C. Trevelyan had a dig in Kent's Hole in October, 1824. Mac Enery states "Though not the original discoverer Mr. W. C. Trevelyan was certainly the first that obtained any results of value to science, of which he had an engraving executed on his return. It exhibited simple teeth of Rhinoceros, Hyaena and Tiger with jaws of the Bear and Fox—and one or two inconsiderable bones" [**31**, p. 207/19]. He also refers to it on p. 443/271. Copies of this plate are at Torquay and Pengelly states they have the following legend : "Teeth and Bones found in Kent's Hole, near Torquay, Devon, 1824, M. Morland del et lithog. Printed by C. Hullmandel London. Pubd. by John Murray. Albermarle St. 1825." One can safely say that the specimens were sent to Buckland and the plate drawn in 1825.

MISSING PLATES.

There are a number of references in Mac Enery's MS. to figures which are presumably on lost plates [**31**].

"Boar spear" (*vid.* Plate) p. 221/33. "Barbed spear of iron," p. 276/88, "Barbed spearhead of iron," p. 449/277.

Mac Enery stresses the importance of this.

Bone weaving comb, "a curious ornament of bone, in shape not unlike a scissors case, pointed at one end and notched like a comb at the other—See Plate —, Fig. —," p. 277/89."

" A pin of bone retaining at one extremity its articulating joint, but shaped at the other to a tapering point, Fig. —" p. 277/89.

" A rude zigzag moulding or notching runs round the edges. See Fig. — [Pottery], p. 277/89.

" Flints. There are a few specimens formed with great art, sharp pointing, sloping and barbed—of which Fig. — is a good example," p. 321/133. Pengelly has stated that this figure is unknown (*op. cit.* note) and he is correct. Nothing on Pl. T answers to this description.

" A curiously formed ornament made of bone, in form resembling a spearhead —Fig. —," p. 446/274.

" I found at Berryhead the half of a circular piece [of slate] perforated in the centre figd—," p. 469/297.

These are all human artifacts and may well have been on one plate.

In addition there are several bones said to be figured, but the figures cannot be traced.

" Large horn, Fig. 1," p. 292/104. This may be a slip for Fig. 3 [Pl. H], the very large Red Deer.

" *Vid.* Radius (perfect of Ox)—" p. 361/189.

" 2 large humeri Fig. —" p. 190/362.

" Hyaena aged Individuals whose teeth are broken or ground down to the fangs or have entirely disappeared by absorption (Plate Fig.)," p. 373/201.

De Blainville has figured a fragment of the mandible of *Canis vulpes* Linné [**9**, Canis, Pl. XIII) after Mac Enery, and this is not on any known plate.

There is a tibia of *Bos* or *Bison* in the Geological Survey Museum (G.S.D 2891, *ex* Geol. Soc. Coll., probably given by W. Long), which still bears the artist's number 7 in pencil.

So it is clear that there are missing plates for the suggestion that there were intended plates will not apply to the two last.

SPECIMENS FOUND BY MAC ENERY AND FIGURED BY OTHERS.

A number of these have not been traced. Sixteen were figured by Owen, nearly all from specimens in the British Museum purchased at the Mac Enery sale, 1842 [**15**].

p. 82, Fig. 25. Jaw of *Ursus priscus* ; not traced.

p. 91, Fig. 29. Canine of *Ursus spelaeus* ; not traced.

p. 92, Fig. 30. Humerus of *Ursus spelaeus* ; not traced.

p. 134, Fig. 51. Jaw of *Vulpes vulgaris* ; Brit. Mus. (Nat. Hist.) No. 16712.

p. 137, Fig. 53. [Jaw of] fossil Fox ; Brit. Mus. (Nat. Hist.) No. 16707.

p. 158, Fig. 61. Lower jaw of young Hyaena ; not traced.

p. 166, Fig. 65. Canine of *Felis leo* ; not traced.

p. 180, Fig. 69. Canine of *Machairodus latidens* Owen. This was in the Museum of the Roy. Coll. Surgeons and may have been destroyed by enemy action.

p. 182, Fig. 70. Incisor of *Machairodus latidens* Owen ; not traced.

p. 201, Fig. 76. Skull jaws and teeth of *Arvicola amphibia* ; Brit. Mus. (Nat. Hist.) No. 15081 = *Arvicola abbotti* Hinton [**77**, p. 414].

p. 206, Fig. 77. Lower jaw, teeth and tibia of *Arvicola agrestis* ; Brit. Mus. (Nat. Hist.) No. 15084 = " probably a rather large representative of *Microtus agrestis hirtus*, the southern section of the species " (M.A.C. Hinton *in litt.*).

p. 208, Fig. 78. Skull lower jaw and teeth of *Arvicola pratensis* ; Brit. Mus. (Nat. Hist.) No. 15095 = " *Evotomys* sp. that is, some form of the Bank Vole, not precisely determinable in the absence of tolerably complete skulls " (M. A. C. Hinton in *litt.*).

p. 212, Fig. 81. Lower jaw of *Lepus cuniculus* Brit. Mus. (Nat. Hist.) No. 15089.

p. 224, Fig. 87. Second molar tooth of *Elephas primigenius* ; not traced.

p. 336, Fig. 126. Fourth right upper molar of *Rhinoceros tichorhinus* ; not traced.

p. 383, Fig. 143. Third upper molar of *Equus fossilis* ; not traced.

It is probable that most of the untraced originals of Owen's figures are in the British Museum (Nat. Hist.) for the casual way with which Owen treated his specimens is notorious.

1842. Falconer and Cautley. *Fauna antiqua sivalensis*, Pl. XIV, Figs, 3, 3a. Third lower milk molar of *Elephas primigenius* ; Brit. Mus. (Nat. Hist.) No. 15001a.

Falconer has described a germ of the left molar of *Elephas primigenius* (Vol. ii, p. 160). Geological Survey Museum *ex* Geol. Soc. Coll. Mrs. Cazalet don. No. G.S. 63 (23416).

De Blainville figures as *Hyaena intermedia* a fragment of ramus with the last three molars given to the Paris Museum by Mac Enery [**9**, Hyaena, Pl. VII]. This is probably still in Paris.

M. A. C. Hinton has figured a right molar tooth in Brit. Mus. (Nat. Hist.) as *Pitymys gregaloides* Hinton [77, Fig. 64, p. 127, No. 12]. This was mounted on a tablet with other specimens purchased at the Mac Enery Sale, the whole being registered as 15084a. The specimen is a fragment of a right ramus carrying the incisor and M.1. and has been removed from the tablet (M. A. C. Hinton in *litt.*). This is of Cromerian age.

M. A. C. Hinton has most kindly placed at my service his notes on the Microtine fauna of Kent's Hole, most of them based on specimens found by Mac Enery.

" In British Museum (Nat. Hist.) :

A. Still on tablet No. 15084a. See above. Four mandibular rami, a premaxilla, and a palate with M.1 on each side, all referable to *Microtus*, but not more precisely determinable.

B. Items removed from the tablets :

1. Fragment of right mandibular ramus with M.1 = young *M. anglicus*.
2. Fragment of right mandibular ramus with M.1 = *M. arvalis* group, probably *corneri*.
3. Fragment of right mandibular ramus with M.1 = *M. ratticeps*.
4. Right mandibular ramus with M.1 and M.2 = *M. anglicus*.
5. Right mandibular ramus with M.1 and M.2 = *M. arvalis* group.
6. Left maxilla with all three cheek teeth = *M. arvalis* group.

All these are of late Pleistocene age, about Ightham fissure stage.

In Bristol Museum, J. Mac Enery don.

No. CA. 6342. *Pitymys gregaloides* Hinton, left mandibular ramus (fragments) with M.1 in place, tooth with three closed triangles, confluent pair and small anterior loop. Rather young.

Arvicola sp. Part of a right mandibular ramus, with incisor M.1 and M.2 ; M.1 with third outer fold well developed, size small, no sign of rooting ; M.1, M. 2, Ca. 6 m.m.

The characters indicate a small early species of the *bactonensis—greeni—praeceptor* group described in 77, vol. i, p. 386 *et seq.* The statement about the pattern of this tooth indicates that it came nearest *A. greeni* from Ostend near Bacton (late Cromerian). This agrees with the *Pitymys* and confirms the view that there are or have been very early deposits in Kent's Cavern. Between 1912 and 1914 I examined a small collection made at that time by Mr. Herron (who to our great loss was killed in the war); [he was a well remembered member of our Association] in Kent's Cavern. This comprised remains of *Lepus anglicus*, *Ochotona* (Pika), *Lemmus lemmus* (a left ramus with part of the incisor and M.1 and M.2 *Evotomys* sp., *Arvicola abbotti*, a fine skull and a mandibular ramus and some lower jaws representing *Microtus arvalis* group (probably *M. corneri*) and *M. ratticeps*. This is a typical Ightham assemblage." I am greatly indebted to the Keeper of Zoology (Brit. Mus. Nat. Hist) for permitting me to place the above identifications on record.

V. THE FLINT ARTIFACTS.

Buckland was the first to find a worked flint in Kent's Hole. This was in January, 1825, and it was described as " the blade of a knife belonging to the Ancient Britons, made of flint, about two inches and a half long and half an inch broad " [**2**]. This is the first record from any cave, and the specimen is probably at Oxford.

In the summer of 1825 Buckland, Northmore and Mac Enery had a dig and the last states : " The only thing of note discovered on that occasion was the tooth of a Rh[inoceros] and a flint blade supposed to be a British relick—both of which it was my lot to find. This was the first instance of the occurrence of British knives in this or any other cave hitherto examined " [**31**, p. 443/271]. This shows that Buckland did not inform Mac Enery of his previous find and that Mac Enery had not seen the notice in the Monthly Magazine. Mac Enery gave the Rhinoceros tooth to " a lady at Torquay," probably Mrs. Cazalet, for he had not started forming a collection [**31**, p. 236/48]. He may well have given the flint to Buckland, and this is the single implement credited to him [**31**, p. 458/286]. In November, 1825, systematic work was begun, and soon a fair number were found. There is an undated list in his MS., apparently an enumeration of the number found and their owners [**31**, p. 458/286]. For the list and a criticism of it see p. 170. Apparently at first he did not accept their artificial nature for he states : " My reserve and repugnance I long showed to admit their artificial origin " [**31**, p. 339/151]. But he changed his views and says : " Into this opinion [i.e. that they were contemporary with the bones] I fell at first from the discovery of flint blades in contact with both [cave earth and bones] in several parts of the cavern and the alternation of the stalagmite and I communicated my impressions to Dr. Buckland with all the earnestness of sincere conviction " [**31**, p. 226/38]. This was probably in March, 1827. In spite of his own find Buckland would not agree for it was opposed to his theoretical views. In an earlier version of his *Cavern Researches* Mac Enery states : " From this period and more especially March, 1827, I attached still greater importance to their presence carefully, cautiously and deliberately scrutinised and noted their localities and looked for fixed and settled ground for building my opinion upon—but this evidence is not perhaps yet complete " [**31**, p. 339/151].

In the same fasciculus he gives a very full account, but it is difficult to understand his views as to their age [**31**, pp. 321/123—338/150]. He had been to Paris and compared them with specimens in the museum and had seen Cuvier, another opponent of Man's antiquity [**31**, p. 325/137], and Mac Enery deferred to " Authorities." However, he could not agree with Buckland, who considered them as Neolithic, and Mac Enery trounces Buckland's theory of " Ovens," a theory only known by this reference [**31**, p. 334/146]. So far as one can gather at this time (1831) Mac Enery thought they were intermediate in age between the deposition of the Cave-earth and that of the upper stalagmite. This opinion is repeated in his latest M.S., Fasciculus A, 1837 [**31**, p. 226/38]. In 1839 Bellamy printed part of an undated letter from Mac Enery, in which he states : " I have found human bones, and works of art, such as pottery and articles of flint, such as arrows, knives, and axes, fabricated of silex beneath the stalagmitic crust, and in association with the relics of fossil mammalia, but decidedly under such circumstances as left no doubt on my mind of their having been introduced *subsequently* to the fossil bones " [**10**, p. 96]. Mac Enery had bowed to authority and had recanted his heretical views. Whether secret pressure from " higher quarters " had been used we shall never know, but it is a sad story. As Sir John Evans said, " That one who observed so well should out of deference to the prejudices of others, has sometimes been doubtful of the evidence of his own eyes and has been driven to postpone until too late the publication of the records of his observations must ever be a cause of regret to all lovers of science and truth " [**38**, p. 443]. One cannot help thinking that there was wishful thinking in Mac Enery's statements, especially those in his latest version, Fasciculus A. Pengelly has contrasted his experience in the " Sloping Chamber " with Mac Enery's account. The latter states : " The [stalagmitic] crust is thickest in the middle . . . for opening the excavation, the same means were employed as to break up a mass of ancient masonry. Flint blades were detected in it at all depths, even so low as to come in contact with the fossil bones and their earthy matrix, but never below them " [**31**, p. 247 59]. Pengelly states : " During the last six months, however, the excavations made in the same chamber, and in the immediate neighbourhood of his, have brought forth Flint implements from every level of the Cave-earth to which the work has been carried, and they were actually found in greatest numbers in the lowest levels. To this may be added the fact that in his [Mac Enery's] heap of refuse-matter, which he had twice examined, there were upwards of a dozen flint tools such as he stated never occurred in the Cave-earth. Had the soil been examined in daylight they could not have been overlooked ; for instead of being specimens of little value, they are better far than some of those which he figured ; and it is but right to add that many of those found by the Committee were overlooked in the first or candle-light search " [**45**, p. 307]. It is fortunate that in an earlier version—Fasciculus C, 1831—is preserved a statement that contradicts Mac Enery's latest version in Fasciculus A, 1837, for it is stated : " If they [worked flints] had been found only in decidedly modern mould or even of mixed character there would be an end of the controversy—but the fact of their occurrence in the lower bed in still greater number than the upper sets the matter at rest " [**31**, p. 336/148]. This confirms Pengelly's observations.

Subsequent excavations by R. A. C. Austen, E. Vivian and especially Pengelly have proved that Mac Enery's first impressions were correct. Excellent accounts of these finds have been given by Miss Garrod [**75**], Sir John Evans [**38, 56**], H. J. Lowe [**71, 72**] and Reginald A. Smith [**67**]. The first has given a full account of the late Palaeoliths, but whether the French sequence can be applied to England is more than doubtful and has caused her to suggest disturbance when there was none. Moreover, there is a total absence of those life-like gravings and carvings in England, for the famous horse's head from Cresswell Crags is of French origin and was put in the cave for the diggers to find, and over the Sherborne carving it is better to draw a veil. Pengelly has carefully placed on record the descriptions and positions of those he recovered, and this must always remain the standard of reference, whilst his discovery of the Abbevillean nodule tools in the Breccia was one of the most noteworthy in English pre-history.

It should be noted that Northmore also found flint implements, for he states : " Several British flint knives were also discovered, one sticking partly in the mud and part in the stalagmite " [**7,** p. 122]. Trevelyan also found flint artifacts under the stalagmite on February 28, 1826, but there is no evidence that Mac Enery knew of this.

Machairodus latidens Owen.

The literature relating to the teeth of this species reflects the muddle arising from the absence of published evidence. When found in January, 1826, Mac Enery states that it was " at first view pronounced to belong to the Saurian family from the serrated beading on its edges " by " the naturalists of this country " [**31,** p. 368/196). To Buckland it was a carnivorous animal of an unknown genus [p.], and this was correct. In March, 1826, Cuvier identified it as his *Ursus cultridens* and under this name its presence in Kent's Hole was well known to the scientific world, although no details were published. In 1843 Owen referred the specimens to *Machairodus*, but gave it no trivial name; measurements of two of the canines were given [**14,** p. 68] and in 1844 he described it as a new species under the name of *latidens* figuring a canine and an incisor [**15,** pp. 174-183]. There is no need to discuss his mistakes and subsequent ones by Dawkins and Falconer, for they were all unaware of the real facts as to the number of canines found. Mac Enery states that five canines were found [**13,** p. 369/197], and since five are known that matter is settled, and this view is supported by Trevelyan, who was at Torquay soon after they were found (Appendix). These may be distinguished as A, B, C, D and E.

A. In British Museum (Nat. Hist.), No. 14954, Dr. Lovell Phillips don., 1842. Pengelly states : " At the Mac Enery sale the lot of three *Machairodus* canines were overlooked by Dr. König, who was buying on behalf of the British Museum, and was bought by Dr. Lovell Phillips and Dr. Battersby. After the sale Dr. König explained the situation to the purchasers, and Dr. Phillips gave the original of Figs. 1, 2, 3 [Plate F] to the National Collection. The same donor gave one specimen to the Oxford Museum, whilst the third passed into the possession of Lord Enniskillen, who gave it to the Royal College of Surgeons " [**31,** p. 491/9 note], see also Falconer [**29,** vol. ii, pp. 459-60].

Figured by Mac Enery (Pl. F, Figs. 1, 2, 3), copied by Dawkins and Sanford [**28,** pl. xxv, Figs. 1, 2, 3], copied by Falconer [**29,** Vol. i, Figs. 8 and 7=2 and 3], who describes it as " Intact germ specimen broken across " [**29,** Vol. ii, pp. 459-460], copied by de

Blainville [**9**, Felis, pl. xvii], copied by M. Boule [**60**, p. 560, Figs. 8-9a = Figs. 1, 2, 3], copied by Boyd Dawkins [**41**, p. 331, Figs. 101 and 102]. There is a cast in the Paris Museum given by Mac Enery. It is a left upper canine.

B. In Geological Survey Museum G.S. 422 (23413), *ex* Geol. Soc. Coll., Mrs. Cazalet don. February 17th, 1826, figured by Mac Enery (Pl. F, Figs. 4, 5, 6), copied by Dawkins and Sanford [**28**, pl. xxv, Figs. 4, 5, 6, explanation is incorrect], copied by M. Boule [**60**, p. 560, Fig. 8B]. Paris Museum has a cast given by Mac Enery. Falconer states that this specimen (29, ii, 413) is " very like the one figured by Owen, but of a different individual," and adds that there are casts in the British Museum and at Oxford [**29**, Vol. ii, pp. 459-60]. It is a right upper canine.

Pengelly has placed on record the gist of a conversation he had with Sir W. C. Trevelyan in 1867 in Kent's Hole, and the latter said that he believes he saw at the end of February, 1826, in the Cazalet and Mac Enery Colls. all the specimens that had been found, but B was then in London in the Geol. Soc. Coll. It is easy to make a mistake when one has only one's memory to rely on after forty years.

C. In Geological Survey Museum, No. 62957. Sir W. C. Trevelyan don. May 15th, 1871. Figured by Mac Enery (Pl. F, Fig. 7), copied by Dawkins and Sanford [**28**, pl. xxv, Fig. 7 explanation is incorrect]. An old label with it states : " Right upper canine of *Machairodus latidens* Owen Kent's Hole, Torquay. Rev. J. Mac Enery figured specimen." This label cannot be earlier than 1844, when Owen described *latidens*. Dawkins and Sanford state : " The fifth, Pl. F, Fig. 7, is in the collection of Sir Walter Trevelyan, Bart., to whom it was given shortly after its discovery by Mrs. Cazalet " [**28**, p. 186]. This statement is based on two letters from Sir W. C. Trevelyan to Dawkins, which are now printed for the first time (Appendix). This tooth being in a private collection was overlooked, and thus caused the trouble as to the number found.

D. In Museum Royal College of Surgeons, England, Lord Enniskillen don. *ex* Mac Enery Coll. See above for the history. This is borne out by a note by Charles Murchison in Falconer's Memoirs : " In a letter from Dr. Lovell Phillips to Dr. Falconer it is stated that the third *Machairodus* tooth at Mc Enery's sale was purchased by Dr. Battersby for ' some nobleman ' " [**29**, Vol. ii, p. 461]. Figured by Owen [**15**, p. 180, Fig. 69] as *Machairodus latidens* Owen but Owen's description was based not only on this specimen, but also on the figures of plate F. Owen's statement that they " were recognised by Dr. Buckland as bearing a close resemblance to the canines of *Ursus cultridens* of the Val d' Arno " [**15**, p. 181] is incorrect. Buckland could not place them. It was Cuvier that identified them as *Ursus cultridens*. It is a right upper canine.

This tooth may have been destroyed by enemy action.

E. In the Oxford Museum. Dr. Lovell Phillips' don. *ex* Mac Enery Coll. Falconer states : " In Prof. Buckland's Coll. is the original *Ursus cultridens* canine of Mc Enery " [**29**, Vol. ii, p. 460]. From the letters at York (Appendix) this tooth was shown by Buckland to Cuvier in March, 1826, and identified by him. There is a contemporary cast at York given by Mac Enery. There is no clue as to where and by whom these casts were made. Sidney Melmore informs me *in litt.* : " On our cast the serrations have clearly been put in with a tool after the cast was made, this detail being too fine to impress itself in the casting." The Oxford specimen has not been figured.

There has been considerable divergence of opinions as to the number of incisors of *Machairodus* found in Kent's Hole. If the published evidence is reliable it is clear that, including the specimen found by Pengelly, five incisors have been found, but only two are known.

1. Figured and described by Owen as a right external incisive tooth and there are no traces of gnawing on the figure, but this is not decisive proof that the tooth was not gnawed [**15**, p. 182, Fig. 70]. Pengelly has placed on record the answers that Owen made to a series of questions respecting the tooth.

" That his figure of the incisor was drawn from an actual specimen and not copied from any other drawing. That he had never seen the drawing. That the specimen he figured was with several other teeth and bones brought to him by Dr. Buckland, to whom they were returned. That he does not know from whom Dr. Buckland obtained it. That the Exeter specimen is a left outer incisor. That he believes it to be the specimen he figured and described in his book. That it was brought to him not before 1844 " [**42**, p. 260].

A period of nearly thirty years had elapsed and Owen had certainly not referred to his *British Fossil Mammals*, for his figure is a right, as he said at the time, and the Exeter specimen is certainly a left. The original of Owen's figure has not been traced.

2. The incisor in the Exeter Museum. Pengelly has given a full account of this [**42**, pp. 247-260]. It was purchased at the Mac Enery sale in 1842 by W. C. Radley, of Newton Abbot, and was sold by him to F. W. L. Ross, of Topsham, *circa* 1853, and on his death was given to the Exeter Museum. It was one of a small series, probably a " lot " at the sale, and it was not recognised for some years. It was first identified by the well-known curator and Palaeontologist, W. S. W. D'Urban, in 1875, and confirmed by Pengelly and others. It is a 3rd left upper incisor and ungnawed. It is a great pity that the British Museum (Nat. Hist.) has distributed casts and, accepting Pengelly's identification and Owen's, described them as being those of Owen's specimen, which they certainly are not, for the histories of the two specimens do not agree. It has a piece of paper adhering to it, evidently part of a

torn-off label with " ear " still remaining. The writing has been identified as that of Mac Enery, and suggested that it should be " bear," but whether Mac Enery recognised it as *cultridens* we shall never know.

3 and 4. The incisors figured by Mac Enery. This is a real muddle, but it can be straightened out. In 1868 Dawkins and Sanford stated : " The incisors of *Machaerodus latidens* are now only known by three figures of the Natural size in a lithograph which they reproduced from a photograph of the original at Torquay [**28**, pp. 187/8, Figs. 1, 2, 3]. Two teeth are represented, both gnawed, Figs. 1 and 2 a left upper incisor, Fig. 3 a left lower incisor. Owen's earlier figure had not been overlooked, for they stated that it was copied from Fig. 3. Owen's denial of this has already been quoted ; their is no resemblance between the figures, and Owen's is a right. Probably Dawkins and Sanford were not to blame in speaking of the drawing as a " lithograph," for they had probably not seen the original, and Pengelly in the following year spoke of it as a plate [**31**, p. 370/198], whereas it is a drawing, but he adds the important fact that the drawing has the legend : " I Scharf del. 1837." Mac Enery in his MS. has placed on record the finding of an incisor. He states : " In the same bed I have lately discovered a small tooth about an inch long," and gives a good description [**31**, p. 370/198], though he has blundered over the size—it should be two inches. In 1831 Mac Enery gave to the Paris Museum a cast of an incisor, and there can be no doubt that this is Figs. 1 and 2. The cast has been figured by de Blainville [**9**, Felis, pl. 17], noted by Gervais [**27**, p. 78] and by Boule, who states that it agrees with Dawkins' and Sanford's figures [**60**, p. 559]. Dawkins reproduced his figures in 1874 [**41**, p. 333, Figs. 103-5]. Pengelly has raised the question as to where they were found, for there is no locality on the drawing [**39**, 1872, p. 172]. One certainly was, and Fig. 3 was probably detected or found between 1831 and 1837, when the drawing was made. Both the teeth are missing.

5. Pengelly's. This is the only one with a full history. It was found " July 29th, 1872, with the left lower jaw of Bear containing one molar in the first or upper-most Foot-level of Cave-earth, having over it the Granular Stalagmitic Floor 2.5 feet thick " [**51**, p. 333]. It is a 3rd right upper incisor not gnawed, and is now in the British Museum (Nat. Hist.), No. M582. Lord Haldon don., 1883. It has been figured by Lyell [**40**, p. 105, Fig. 10, A, B, C], and in *Memoirs of W. Pengelly* [**57**, plate facing p. 261].

The question as to who found the canines is of no great importance. Mac Enery states that they were found, and makes no personal claim [**31**, p. 369/197], and it must be left at that. There is, however, the question as to where they were found, and the answer is clear ; they were found in the cave-earth. Mac Enery's account of them, though rather involved, makes it fairly certain that was the bed [**31**, pp. 368/196—373/201]. Trevelyan from his letters thought it was the cave-earth [p. 167], and Pengelly's incisor certainly was.

So far as our present knowledge goes, *Machairodus* is quite out of place in the cave-earth, and its correct level is the Breccia. H. Breuil has recorded *M. latidens* from the lowest bed at Abbeville, the specimens being part of maxilla with two molars, an isolated molar and a canine [**84**, pp. 21-2]. This bed has yielded flint implements identical with the nodule tools from the Breccia. A few of the Microtine remains are also of an early type, so it is clear that earlier beds are present in the cave. But how did the teeth get in the cave-earth? Apparently Mac Enery saved every sizable fragment and yet no other bone was found, so there can be no question of selection by the workmen as at Abbeville. I would suggest it was human agency; Man brought them to where they were found as " curios " or for use; he certainly used Bears' canines from the Breccia as tools. Rooke Pennington has placed on record that Professor Capellini of Bologna told him that teeth of *Machairodus* are found deposited as amulets in Prehistoric Italian tombs [**44**, p. 104]. Elsewhere in England *Machairodus* has only been recorded from Cresswell Crags [**43**, 1877, p. 594] and the Forest Bed [**33**, **50**, **54**].

It is better to forget the former record. Though T. Heath states his case very badly [**47**, **48**], if one reads his pamphlets one can only conclude that the tooth was put there for the diggers to find. I am told that, judging from the matrix, it is an Italian specimen. The Forest Bed specimens are quite another matter, for they are in their correct statigraphical position. They are part of a canine from Sidestrand described and figured by Ray Lankester [**33**] and E. T. Newton [**50**], the lower end of a fibula from Bacton described and figured by E. T. Newton and assigned to *Machairodus* with a doubt [**50**], and a mandible from Kessingland described and figured by Backhouse and Lydekker [**54**]. Part of a humerus from Kessingland described by E. T. Newton [**50**] is possibly *Machairodus*.

M. Boule has noted that M. Fabrini considers the Forest Bed specimens to be not *latidens* Owen, but *crenatidens* Fabrini described from Val d' Arno [**60**, p. 567]. This is a case for specialists, and I can offer no opinion. *M. latidens* is known from several French caves (there is a fairly complete skeleton in the Paris Museum), but M. Boule, whose recent death we all deplore, states that the Lion and *Machairodus* never occur together in the same cave [**65**]. This is characteristic of the " great cats," for the Lion and the Tiger never occur in the same area. This disposes of the view that *Machairodus* was a " relict " species in S. Devon, for the Lion was found by Pengelly to be about one per cent of the teeth found.

Note.—E. T. Newton at the meeting of the Geological Society, when the mandible from Kessingland was described [**54**], exhibited an incisor from the Forest Bed, but no details were given.

(*To be continued in next part of " Proceedings*.")

THE EARLY DIGS IN KENT'S HOLE, TORQUAY, AND MRS. CAZALET.

(*Continued.*)

VI. WHO WAS MRS. CAZALET?

My interest in this question was aroused on seeing the fine series of figured and important specimens given by her to the Geological Society on February 17th, 1826, and now in the Geological Survey Museum. This series includes all the figured flint implements, the only figured human bone, as well as one of the three figured canines of *Machairodus*. She also had owned a second figured canine, which she gave to Sir W. C. Trevelyan, by whom it was presented to the Museum of Practical Geology. In addition, C. D. Sherborn had noted there were eight other specimens in her donation marked with the artist's numbers in pencil, but had failed to trace the plate [**61**]. There can be no doubt that this is the unpublished Plate O, containing twenty-one figures. Copies of this plate are at Torquay and I regret that I have been unable to inspect them, but the probability is that the originals of all the figures are in the Geological Survey Museum. The literature is singularly silent about her, and she is dismissed by Pengelly with the remark, " Mrs. Cazalet mentioned above was a co-religionist of Mr. Mac Enery and her fine collection is known to have been made up at least very largely of the presents he made her from time to time " [**49**, p. 384]. I am doubtful if he ever saw the collection in the Museum of the Geological Society, for it was safely buried. If he had seen it I am certain that he would have " spotted " the flints as the figured ones, and I am certain that he never saw her labels, or he would never have written the paragraph. I therefore made an examination of all the available evidence, and am able to throw a little light on the subject, though enquiry in the present family by Day Kimball was fruitless. The collection given to the Geological Society consists of 106 specimens, and is clearly a selection of the best and most perfect specimens, especially of the smaller bones. There is only one large bone, " part of tibia of Hippopotamus," No. GS124. This requires re-examination, for the occurrence of this animal in Kent's Hole is denied by Pengelly [**34**], additional proof that he had not seen the series. Possibly the drawers of Mrs. Cazalet's cabinet were rather shallow and the only tooth of *Elephas primigenius* is a germ tooth. In addition to the specimens already noted there are many bones of the Hare (*Lepus variabilis anglicus* Hinton), a perfect humerus of the Wolf (marked as figured), four canines of Lion, and jaws and bones of Hyaena. The collection must be seen to be appreciated at its true value. Besides this series Mrs. Cazalet retained a large number of specimens described by Trevelyan in his diary : " 27th Feb., 1826. Saw Mrs. Cazalet's coll. of bones from K.H. Very fine Bear, Tiger [**21**], Wolf, Hyaena, Elk, Ox, Horse, Elephant, Rhinoceros, flint Knives " [p. 206]. Three of her original labels have survived. Limestone pebble No. G.S. 157 (23457)—" This is the finest specimen we have found." Mac Enery in his MS. records finding similar pebbles [**31**, p. 283/95]. Two fragments of tusk of *Elephas* Nos. G.S. 89 and 90—" We think this is fossil ivory ; if so please return one specimen for my cabinet." Mac Enery has noted finding a crushed tusk of *Elephas*, " a piece of about a foot long was extracted tolerably perfect " [**31**, p. 294/106]. It probably fell to pieces after extraction, as every geologist knows who has tried to extract an Elephant's tusk, and they did not know then how to preserve them. Mac Enery's letter to Trevelyan, June 19th, 1826, throws some light on the problem. This shows that there was a Mr. Cazalet, that he was a friend and was interested in Kent's Hole and that Trevelyan had met him and that he had left Torquay and was then living " beyond Newton," and was thus taking no part then in the dig [p. 203].

Mrs. Cazalet's donations to the Geological Society were :

" 1826, Feb. 17th. Bones from Kent's Hole, Torquay. Mrs. Cazalet " (*Trans. Geol. Soc. Lond.*, Ser. II, Vol. ii, list of donations unpaged).

" 1827, April 6th. Recent and fossil corals from Torquay, Bovey Coal. Mrs. Cazalet " (*op. cit.*).

On the same date she gave, though not recorded, a cast of the upper jaw of *Felis spelaea* G.S. 111, date of gift on specimen. The original of this was in the Mac Enery Coll. on May 3rd, 1826, but in August, 1827, when it was drawn—Pl. C, Fig. 1—it was stated to be in the possession of Sir L. V. Palk. Probably also on April 6th, 1827, she gave a cast of a tooth of *Elephas primigenius*, G.S.D. 3821, still bearing her label, " the largest specimen found." The original is probably the tooth found by the Rev. F. Belfield and noted by Mac Enery [**31**, p. 249/67]. The fossil corals given by Mrs. Cazalet cannot be traced, nor the Bovey Coal, but there is still a specimen of Beekite in the collection, given by her. One must emphasise the difference between the label on the Limestone pebble and that on the cast of the Elephant's tooth. The omission of " we " is of great importance. An examination of Mac Enery's MS. reveals similar differences. If he uses " I " it always refers to his own observations or to his two preliminary digs. He gives a long list of helpers (but does not mention the Cazalets), and duly records the more illustrious names as finding bones. He also notes the more important finds and the finders' names of those persons who were digging independently. Otherwise it is always " we found " or the impersonal " were found," the latter phrase being used when describing the canines of *Machairodus*, though he uses " I found " for his own discovery of the incisor. There are only two direct references in the MS. to Mrs. Cazalet :

" *Cervus megaceras*, base of antler. One in my coll., another in Mrs. C., and perhaps a third in G. Society " [**31**, p. 410/238]. This looks as though Mrs. Cazalet had two out of the three found. In Fasciculus J is a list headed " Flints." It is apparently a list of flint artifacts found and their possessors, and Mrs. C. is credited with six and the Geological Society with two [**31**, p. 458/286], whereas Mrs. Cazalet gave nine to the Society and still retained a number. Apparently Mac Enery took no account of what Mrs. Cazalet did have and relied on his memory. There is one other probable reference. " In this loose heap it was that I found the first Rhinoceros tooth, which I presented to a lady at Torquay who had a collection of objects of Natural history from the environs—I had not yet commenced forming my own collection " [**31**, p. 236/48]. Mrs. Cazalet certainly answers to the description. There is one statement in the MS., alas undated, but certainly is *post* October, 1825. " Hitherto I labored alone with a pavior's pick. I now proceeded to excavate occasionally, assisted by persons of great intelligence and experience. Half a dozen workmen properly appointed labored hard in cutting away the crust." And on the same page he notes finding polished pebbles [**31**, p. 283/95]. This statement can be read in two ways ; either that he " excavated occasionally " or that he was " occasionally assisted." I think the former is the correct reading. So far as we can gather Mac Enery was not a rich man, and an excavation on the above scale was expensive. I think that the explanation of the above citation is that the " persons " were the Cazalets and they paid the expenses. From the above evidence one can deduce that the Cazalets took an active part in the work between November, 1825, and the date when they moved from Torquay, which was before June 19th, 1826. Mrs. Cazalet certainly had the pick of the finds before February 17th, 1826, and her collection was so good that it was largely drawn upon to furnish specimens for the plates, though Mac Enery continued his diggings for some time after February 17th, 1826. The only conclusions one can come to is that the Cazalets assisted in the work and paid the expenses.

Why Mac Enery nearly ignores them altogether is a mystery, but we must remember that the MS. are very imperfect and that the only surviving parts of the " Preface " are two fragments [**31**, pp. 440/268—443/271]. One has to be thankful that her specimens were buried in the Museum of the Geological Society, and except for careful identification by W. Lonsdale and Dr. H. Falconer, whose labels are still on many of the specimens, the collection is probably as given and the original labels have enabled justice to be done to the memory of the Cazalets.

VII. THE STORY OF THE EARLY DIGS.

1823. Buckland published his great work *Reliquiae Diluvianae*.

1824. (Summer). J. Northmore of Cleeve, Exeter, whilst on a holiday at Torquay is shown the book by his brother-in-law Capt. Welby.

Northmore reads it and decides to dig in Kent's Hole with a double purpose to obtain bones and to prove that it was a Mithraic temple. There are fashions in geology as well as dress. Then Mithraic temples and Universal Deluges were the fashion. Now it is Varve clays and multiple glacial periods, but

"Our little systems have their day,
They have their day and cease to be."

It may well be that our views will in the future receive the same treatment as we mete out to those of the early workers, a smile.

1824. Sept. 21st. Northmore, accompanied by two hired assistants and a draughtsman, dug in Kent's Hole and Northmore proved to his own satisfaction that it was a Mithraic temple, and he obtained, apparently, about thirty bones and teeth. He informed Buckland about the bones.

1824. Oct. Sir W. C. Trevelyan dug in the cave and found bones which he sent to Buckland, who had a plate drawn of some of them. The plate was published in 1825 by Murray's. It is, of course, possible that Buckland told Trevelyan of Northmore's find, but there is no evidence to that effect.

1824. Nov. 14th. Buckland, writing to Trevelyan, said he would try to go to Devonshire in the following January and would visit Kent's Hole and the Pixies' Hole, Chudleigh.

1825. Jan. Buckland, Northmore and Sir Thomas Acland had a dig, and found bones and a flint implement. I have based the month on Buckland's letter quoted above and the fact that he gave a specimen of breccia from Chudleigh to the Geological Society on Feb. 18th.

1825. Summer. Buckland, Mac Enery and Northmore dug in the cave. Mac Enery found a Rhinoceros tooth and a flint implement. It is probable that the latter was recognised by Buckland.

1825. Oct. Northmore organised a large party for a dig and Mac Enery went with them. Mac Enery left the party and dug on his own, for he wanted to send the specimens to Buckland. He found a number of bones, but kept that a secret and sent them to Buckland, who made a plate from a selection. By inference Buckland urged him to continue the work, and probably in November Mac Enery, with the Cazalets and hired labour, started. Pengelly has printed a letter from Mr. Minifie of Baltimore, U.S.A., who was a boy at Torquay at the time. He says "having had the free use of the cavern for so many years people were much dissatisfied at its being locked up: much grumbling against Sir Lawrence Palk and Mr. Mc Enery was the consequence. I believe the gate was several times broken open," and he relates how he once did it [**45**, p. 159]. This will account for a passage in Mac Enery's MS. where he describes the "bears' den" and the many skulls that were found there "while they lay in the chamber awaiting their removal some persons who had heard of the discovery broke into the cavern and either tore away or disfigured the masses." [**31**, p. 239/51]. A sad case of petty spite.

1826. Jan. *Machairodus* canines found and sent to Buckland. Mrs. Buckland drew three of them and Buckland had casts made of two. He retained one tooth and returned the others.

1826. February. The Bucklands go for their honeymoon on the Continent. The exact date is not known, but they were in Paris on Feb. 25th. In spite of the occasion Buckland took with him two casts of the canines and a number of bones sent by Mac Enery as a gift to Cuvier, and one tooth to be shown to him.

1826. Feb. 17th. Mrs. Cazalet presented to the Geological Society the fine series now in the Geological Survey Museum.

1826. Feb. 27th. Trevelyan inspected the collections of Mrs. Cazalet and Mac Enery. That of the former Trevelyan describes as "very fine," and he enumerates some of the species. This was after the series had been given to the Geological Society.

1826. Feb. 28th. Trevelyan, with four workmen, dug for seven hours and found a number of bones and flint implements under the stalagmite.

1826. March 6th. Cuvier identified his *Ursus cultridens* from the tooth and casts submitted by Buckland.

1826. April. In the *Edinburgh Philos. Journal* for this date is an anonymous contribution under the heading "*Professor Buckland's notice of the Hyaenas' Den near Torquay.*" This is the first published account of the results of Mac Enery's work. It would appear that before Buckland left England he sent a series of bones exMac Enery to Prof. R. Jameson to prove that it was a Hyaenas' den, with an account of what had been found and he noted "an unknown carnivorous animal at least as large as a tiger, the genus of which has not yet been determined." This is the first published record of *Machairodus*. It is probable that nearly all of this article is by Buckland, with a little editing by Jameson.

1826. May 3rd. Mac Enery sent a series of bones and a cast of a *Machairodus* canine to York accompanied by an account of the cave, a list of the animals found, and copies of letters from Buckland and Cuvier referring to the specimens.

1826. June 19th. In a letter to Trevelyan Mac Enery states that the Cazalets had removed to "beyond Newton," and that he intended to publish an account of his work.

1826. Dec. 6th. Dr. Beeke, writing to Trevelyan, says that Mac Enery thinks there is very little more to be found and that he has prepared the materials for an account of the cave so far as his own observations go.

1827. March. Buckland visits Torquay, an agreement is made with Mac Enery for the drawing of eighteen plates by G. Scharf to be used by both. Apparently Mac Enery's original work was to be on a small scale. Probably he was overpersuaded by Buckland to make it a monograph with full details as to the anatomy and ecology of the various animals found. It is clear from his MS. that Mac Enery endeavoured to do this by extensive research into all the available literature. The plates were drawn on stone between May, 1827, and March, 1828.

1827 or 1828. Prospectus issued.

1829. Aug. 19th. Latest known date for digging though this probably extended to the following year. The statement in Fasciculus D [**31**, p. 370/198] that he had lately discovered an incisor of *Machairodus* cannot be later than 1831, for in that year a cast was given to the Paris Museum by Mac Enery.

1831. Mac Enery visited Paris. Saw Cuvier and gave him specimens.

1834. Midsummer. Pengelly states that he visited Kent's Hole for the first time on that date and that Mac Enery's researches had for some time been abandoned [**49**, p. 385].

1837. Mac Enery had a drawing made of two incisors showing he was still hoping to publish his book and in the same year he probably wrote Fasciculus A.

1841. Feb. 18th. Mac Enery died.

1842. Sale of Mac Enery's collection.

1847 (before June 16th). Mac Enery's MS. in the possession of W. Long.

1859 (early). E. Vivian published *Cavern Researches*.

1869. W. Pengelly published the whole of the MS. so far as it related to Kent's Hole.

It is curious that ill luck seems to have accompanied all the digs in Kent's Hole, for not one has been properly described.

Pengelly's report, so far as he was concerned, on his big dig from 1865-1880 is a model, but the objects found have never been properly recorded. They have been dispersed amongst various museums, and that is all we know. Dawkins and Sanford drew up a list of many of the bones, but it has never been published, but it is probably preserved in the Pengelly MS., which are in the library of the Royal Society. It is to be hoped that some young and enthusiastic member will undertake the work of examining these papers and place on record the facts as to the animals found, the percentages of the various species and what bones were found and their positions. Until this is done the evidence from Kent's Hole must be used with caution. All letters to Mac Enery were apparently destroyed, and Pengelly states: "His executor, Mr. Kilby, who was an excellent chief of police at Torquay, but without scientific tastes or knowledge or acquaintances as such" [**42**, p. 258], hence our loss. He did, however, keep the proofs of the plates and the drawing, which are now the property of the Torquay Nat. Hist. Soc. I have stated my version of the early digs, and it differs from the usually accepted one. It is unlikely that much fresh evidence will be forthcoming, but the contents of his will should be no great difficulty in placing on record. It is not a pleasant story, but such is life. We who view things from a different viewpoint can excuse the mistakes that Mac Enery made and will esteem the solid contribution he made to Pleistocene Geology.

VIII. APPENDIX.

The Monthly Magazine or British Register, 1825.

In the April number of this journal, under the heading of "Provincial Occurrences, Devonshire," appeared the following:— "*Organic Remains in Kent's Hole and Chudleigh Cave*. The celebrated Professor of Mineralogy and Geology in the University of Oxford, Mr. Buckland, has been on a visit to Lord Clifford in company with Sir Thomas Acland, and has examined the cave at Chudleigh, known by the name of the Pixy's Hole; here he penetrated the Stalagmite, and sunk to the depth of three or four feet, and found various remains of antediluvian animals: such as the hyaena, the deer, the bear, etc. The depth of the den where these remains are found is a matter only of conjecture, but the discovery is, we understand, to be followed up. The Professor has also visited Kent's Hole, and commenced his operations in the two caves where Mr. Northmore had made his original discoveries; among other treasures we hear that Mr. Buckland discovered the blade of a knife belonging to the Ancient Britons, made of flint, about two inches and a half long, and half an inch broad. The public, we understand, are likely in the course of the present year to have the gratification of perusing an account of these antediluvian curiosities in the expected new edition of Mr. Buckland's work, if not also from the pen of Mr. Northmore" (Vol. lix, pp. 190-1). Pengelly [**31**, 1869, p. 194/6].

In the *Edinburgh Phil. Journ.*, April, 1825, is a slightly condensed account, but no mention is made of the flint knife, but the additional information that remains of Hyaenas, Bear, one Rhinoceros and two or three only of the horse were found. This latter account is copied verbatim in the *Annals of Philosophy*, N.S., Vol. ix, June, 1825, p. 470.

These are clearly " inspired " and are by Northmore, and we are greatly indebted to him. This is the first record of a flint implement from any English cave, and it was found by Buckland, and for some reason he never mentioned the fact to Mac Enery. From the dimensions the artifact may be identified at Oxford, and it is certainly of historic importance. The date of the dig is probably January, 1825, for Pengelly has quoted from a letter of Buckland's to Trevelyan dated Nov. 14th, 1824, stating that he [Buckland] would try to go to Devonshire in the following January, when he would visit Kent's Hole and the Pixies' Hole [**45**, p. 167].

The Edinburgh Philosophical Journal, April, 1826, Vol. xiv, pp. 363-4.

" *Professor Buckland's Notice of the Hyaena's Den near Torquay.* —Professor Buckland has lately sent to Professor Jameson, for the College Museum, several specimens of bone from the Hyaena's den at Kent's Hole, near Torquay, all of which he considers as bearing most decided marks of teeth and gnawing upon them. Three of these bones (Nos. 4, 5, 6) are splinters, which appear to have been gnawed and nibbled over and over again, after they were split off from the cylindrical bones of which they formed a part. Other splinters have not been gnawed after such fracture ; but of these none have been sent at present.—Professor Buckland's sole object being to produce conviction in those who deny the fact of the marks of teeth and gnawing being visible on the bones found in our English hyaenas' dens. Numbers 1, 2, 3 are portions of cylindrical bones, from which both extremities or condyles have been gnawed off at a period antecedent to that when they, as well as the splinters and teeth that accompany them, were imbedded in the mud and gravel that now surround them. Of more than a thousand bones, or rather fragments of bones, that have been collected recently in Kent's Hole, not fifty have been found entire. The condyles, and softer portions, are almost uniformly removed, and marks of gnawing and fracture, such as appear in Nos. 1, 2 and 3, are generally visible at the extremities of the remaining central and harder portions. The condition of the teeth—the number and varieties of the animals—and the circumstances that accompany their mangled remains, are precisely the same as at Kirkdale ; the only difference is, that at Torquay the cave is more than twenty times as extensive as that in Yorkshire ; and the remains of all kinds, nearly in the same proportion, more numerous. The superficial crust of stalagmite, and the bed of mud which forms the matrix of the broken bones and teeth beneath it are also in the same proportion thicker. There are also *album graecum*, as at Kirkdale and stumps of gnawed horns of Deer ; and the bony bases of horns of Rhinoceroses, but no *horns of this animal*, although more than a hundred of its teeth have been already found ; also the teeth of many infant elephants,—numberless bones of horses, elks, deer, and oxen—and gnawed bones and jaws of hyaenas with their single teeth and tusks ; also the teeth and tusks of bears, tigers, wolves and foxes,—and of an unknown carnivorous animal, at least as large as a tiger ; the genus of which has not yet been determined. All these will be described in Professor Buckland's second volume of *Reliquiae Diluvianae*. The history of the Torquay cave being, according to Professor Buckland, identical with that of Kirkdale, is totally different from that of the cavernous fissures at Plymouth and Banwell ; both the latter containing bones that are usually entire, and never gnawed ; and which appear to have been supplied by animals that fell into the open fissures, before they were filled with the mud and gravel that now envelope their bones."

This is the first good account of the cave and its contents, and was probably written by Prof. Jameson, based on the information sent with the bones by Buckland. As to the date it must have been written before Feb. 25th, 1826, when Buckland was in Paris. Mac Enery probably started his systematic digging early in November, 1825, and he must indeed have had a rich harvest to obtain over 1,000 specimens in three months. It is clear also that Mac Enery was informing Buckland of the results of the digging, and that Mac Enery was already a good vertebrate palaeontologist and could determine the genera if not the species. The reference to the " unknown carnivorous animal " is of great importance, showing that Buckland had seen the *Machairodus* teeth and did not know them, but of course by the time this notice was printed Cuvier had identified them as *Ursus cultridens*.

This gift of bones is noticed by Buckland in his letter (March 14th, 1826) [p. 203]. The *Edin. Phil. Jour.* had a wide circulation and great publicity would be given to the work at Kent's Hole, and one can understand why it was visited by so many interested folk. This notice was reprinted by Pengelly [**31**, pp. 194/6—195/7].

A letter from the Revd. J. Mac Enery to the Yorkshire Philosophical Society with specimens of bones, teeth and casts, and copies of letters from Buckland and Cuvier. It is dated " Torquay, May 3, 1826," and was read at the meeting, July 4th, 1826. An epitome of the letter and the President's remarks was published the following year in the annual report of the Council [**4**, p. 13].

Sir,—I have the honour to present to the York Philosophical Society through the medium of a highly esteemed member, Mr. Strickland, some specimens from my discoveries in Kent's Cavern, Devon, as a small accession to the Fossil Remains from Kirkdale. There are many points of resemblance between both Caverns, as by reference to the subjoined communications from our most celebrated geologists will appear. Of the quantity, variety and remarkable condition of the Teeth and Bones, a detailed account probably will be given to the public. For the present it may suffice to observe that they have been found in a limestone rock nearly 700 feet in length, having various offshoots and undervaultings as yet unexplored. Diluvial mud overspreads the floor to a depth not yet satisfactorily ascertained though we have dug with that view 10 feet perpendicularly and have not found the original surface—bones are extracted from the lowest excavation. Ledges of limestone prevent our descending to the actual floor, but no doubt we shall eventually succeed. The organic remains are embedded in mud interspersed with angular fragments of limestone, and in some instances rolled pebbles—the superior surface of the mould is rough like the broken stones and gravel in a new road—it grows fine and sandy and free from pebbles as you descend. The bones enclosed in the upper part of the soil are fresher and seem more recent than those buried beneath. The same species, however, are found at the various depths. The larger bones lie thickest at the bottom, where their weight carried them through the liquid mud, which I may remark is moistest near the surface, perhaps from the percolation of water through the porous crust, or that the subjacent limestone has absorbed the moisture of the earth immediately incumbent on it, but of this I do not pretend to give an opinion. The limestone is nearly decomposed. The covering of stalagmite varies, in some parts it is a thin sheet through which the bones protrude as in Kirkdale, in others, as for instance in that which overspreads the bed, whence the greatest treasures have been extracted, it grows to the thickness of four feet, embracing loose stones as they happened to fall from the roof, or to roll from the higher level ; in some places purely a deposit of lime of an undulating surface, firm towards the top, but spongy and crumbling where it comes in contact with the mud. I have contrived so to excavate as to leave this crust untouched. It presents the various stages of stalagmitic formation ; it overhangs like a vault the whole extent of my excavation and future visitors will thus be enabled to form their own judgment of its date and of the antiquity of the bones still to be found wedged between rocks at a great depth below. Teeth and bones of the Hyaena and Bear are dispersed through the remotest and narrowest chambers, but I have not yet found the various species accumulated together except in one particular spot. As you enter from the mouth of the Cave the floor slopes down about 30 feet below the higher level. Whether the bones had been rolled down by a rush of waters from the higher ground, or had been confusedly heaped together by the animals who broke and gnawed them in this their den, perhaps it is immaterial to know ; but certain it is that they are found only *here* in abundance and in all the variety of species. It is equally certain that the condition of the bones bears evidence of the traces of carnivorous animals. Only a few out of thousands have escaped fracture, the splinters, which abound, fit into the breaches in the cylindrical form of the bones and may be restored to their places, having been rejected as too hard for mastication, or as less inviting to an appetite greedy for the marrow and more nutritious portions of the bone.

It is worthy of remark that the Humeri, Tibia, etc., are all broken in one particular way (as may be seen in the numerous specimens in my possession) which would lead one to conclude that it was by the agency of one particular species this violence had been effected and from the fact that the teeth and jaws of the Hyaena most abound in that bed and through the cave, it is not unreasonable to conclude that in Kent's Cavern as in Kirkdale that animal has been the destroyer. Of one of those jaws I have the honor to send a cast, as also one of the Feline, a large Tiger or Lion. The length of the tusk in this jaw exceeds by half an inch the dimensions of all the other Tigers' teeth found in the cavern. I likewise beg to send a correct cast of one of the serrated teeth of the *Ursus cultridens* of Cuvier, whose opinion as well as Dr. Buckland's, on the discoveries in Kent's Cave, by Mr. Strickland's desire I enclose ; at whose request I have supplied the above hasty notice of the circumstances likely to throw light on the collection he is so good to take charge of and present.

I am sorry that casts have not yet been executed of the curious Elephant's teeth found there also. I possess a series to the number of forty (the total number found and which I preserve to be submitted to Cuvier) from the milk teeth to the mature and decayed. There seems to be more than one species. I beg your indulgence for the length of this communication and have the honor to remain, Revd. Sir,

Yr. obedt. servt. J. MC ENERY.

Torquay, May 3, 1826.

This is the earliest account by Mac Enery that is known. It shows that Mac Enery was not a mere "treasure hunter," but was a seeker after truth. Very cautious, he weighed all the evidence before arriving at a definite conclusion, usually being content to state probabilities and leaving it at that. He certainly possessed a scientific mind and was well equipped mentally to undertake a cave exploration, which is more than can be said of some of his successors. This letter was first printed by Pengelly [**37**, pp. 472-474] and has lately been reprinted by Sidney Melmore [**85**, pp. 148-150].

LIST OF ANTEDILUVIAN ANIMALS FOUND IN KENT'S CAVERN DEVON.

This list was sent by Mac Enery with the above letter.

Hyaena. Jaws and teeth in great abundance.
Tiger. Large jaw, some fragments numerous teeth and tusks.
Wolf. One perfect jaw and teeth and tusks.
Fox. Jaw and other remains.
Weasel. Few jaws.
Elephant. About 40 teeth of various form and size. Decayed tusks.
Rhinoceros. Two fragments of jaw and great quantity of teeth of all sizes and ages.
Mastodon. Teeth supposed to belong to that animal.
Horse. Innumerable teeth some jaws.
Ox. Several teeth.
Deer. Of elk one perfect jaw fragments of jaws and teeth. Jaws and teeth of several species of deer.
Rabbit or Hare. Some jaws, etc.
Water Rat. A few perfect jaws.
Mouse. Ditto.
Birds. Several *ulnas Radii*, etc., etc.
Boar 1 tusk.
etc., etc.
etc., etc.

Horns of Deer, Elk, and apparently other animals. The circumference of largest horn at the base 12 inches and 3 lines. Fragments of tusks of Elephants much decomposed.

Similar collections to the one now forwarded have been transmitted to Cuvier for the Paris Museum, to Professor Buckland for the London G. Society and to Bristol.

If this list is reliable the skull of Hyaena and the skull of a Wolf must have been found after May 3rd, 1826, and it is unlikely that Mac Enery would have omitted them, for he was rightly proud of these specimens. It is true that he omits *Ursus cultridens* from his list, but since he had sent a cast of a canine and specially mentions it in his letter he may have thought that no further mention was needed. The list was printed by Pengelly [**37**, pp. 472-4].

EXTRACT FROM DR. BUCKLAND'S LETTER.

To the Revd. J. Mc Enery.

Lyons, 14 March, 1826.

My dear Sir,

I should have forwarded the enclosed [i.e. Cuvier's letter] from Paris had I not waited to visit a spot in Auvergne where they have recently discovered a deposit of animals exactly similar to those of Kent's Cave in a bed of Diluvial sand and gravel. The resemblance is still more striking from the fact of there being among them the teeth of your unknown animal which turns out to be the

Ursus cultridens of Cuvier which had till now been found only in the val d'Arno. There is an entire skull of this Bear in the Collection at Florence.

I think it is more satisfactory to have this analogy established than to have discovered a new species at Torquay.

M. Cuvier was much pleased with the identity of the teeth and more so with your present—and gave a lecture on your bones to the Bavarian ambassador at his soirèe, pointing out particularly the marks of gnawing on the bones.

I have sent the gnawed fragments you gave me to Scotland and trust that on this opposition in that quarter will have ceased. . . .

This fixes the date and by whom the *Ursus cultridens* were determined and throws considerable light on the notice in the *Edinburgh Philosoph. Journal*, April, 1826. [3, pp. 363-4].

It also shows that the legend on Plate F must have been written after March, 1826.

This letter was printed by Pengelly [**37**, p. 475].

LETTER FROM BARON CUVIER.

Monsieur,

Mon confrere Mr. Buckland vient de me remettre les ossemens fossiles de la caverne de Kent que vous avez bien volu m'envoyer. Je m'empresse de vous offrir non seluement [*sic*] mes remercimens, mais encore ceuz de tous les professeurs qui composent l'administration de Museum d' histoire naturelle, car je me suis empressé de les deposer au cabinet du Roi sous le nom du Donateur.

L'etat dans lequel on trouve ces os est un caractere plus marque dans les cavernes d' Angleterre que dans toutes les autres, et qui semble en effet d' montrer que les animaux dont elles recelent les debris ont servi de pature à ceux d'entre eux qui étaient les plus feroces et les plus carnassurs ; c'est ce qui explique surtout l'extreme abondance des os d'Hyene que l' on y rencontre.

Agreez je vous prie, Monsieur, avec le temoignage de ma connoisance, l'expression des sentimens de la haute consideration avec laquelle j'ai l' honneur d'etre,

etc., etc.

B. G. Cuvier.

au Revd. Mr. McEnery.
Paris le six Mars 1826.

This letter was printed by Pengelly with an English translation [**37**, pp. 475-6].

LETTER FROM MAC ENERY TO SIR W. C. TREVELYAN,
dated June 19, 1826.

My dear sir. I feel much obliged by your introduction of Mr. Bald- . . . I accompanied him to the cave shewed him whatever was interesting in a geological light in the vicinity. Next day I introduced him to Mr. Cazalet, who has removed beyond Newton. I made him a convert to Dr. Buckland's theory of the introduction of bones and gave him from the excavations a specimen or two of gnawed bones to show his friend Dr. Fleming . . . What will be his [Buckland's] delight when he hears that I have found 10 feet below the surface, a perfect skull, with teeth entire, processes perfect, of a full grown Hyaena ! One of the underjaws is missing. . . . I have added considerably to my Elephants, Rhinoceros, Elks, Deer and Bears. I have some teeth of the last of great size. A large Tiger's, perhaps Lion's, jaw now embellishes my coll.

The open chamber where you excavated so successfully has been long exhausted. Some plain account I intend to publish when the Professor returns. Mrs. Buckland proposes doing us the honor of a visit when I hope to have collected abundant materials for her pencil. . . .

J. Mc Enery.

Torquay, June 19, 1826.

Printed by Pengelly [**45**, pp. 143-5].

This letter shows (1) that Mr. Cazalet was interested in Kent's Hole and that Trevelyan had met him ; (2) that since his visit (Feb., 1826) Mac Enery had found the skull of Hyaena (Plate G) ; (3) that the upper jaw of Lion was in Mac Enery's possession and must have been given later to Sir L. Palk, though it afterwards reverted to Mac Enery ; (4) that the Cazalets had left Torquay and gone to " beyond Newton " ; (5) that Mac Enery intended to publish an account of his work ; (6) that Dr. J. Fleming was the principal opponent to the view that the bones had been gnawed by Hyaenas. It may be noted that in his work, *A History of British Animals*, 1828, no mention is made of Kent's Hole and that in his remarks on " Extinct Hyaena " he cites Buckland's opinion without comment [p. 16].

LETTER FROM THE REV. DR. BEEKE, DEAN OF BRISTOL, dated Dec. 6, 1826, to SIR W. C. TREVELYAN.

Mr. Mac Enery has arranged his Kent's Hole Collection very neatly and had added a fine scull of an Hyaena somewhat larger than the one which Scharf has engraved and the upper part more perfect but the lower jaw almost wanting. He appeared to think that very little remains worth digging for. He has prepared the materials for an account of the cave so far as his own observations extend, but waits for Dr. Buckland's advice and assistance and no drawings have yet been made of the more important bones I understand that Buckland has returned but I have not yet had any letter from him."

Printed by Pengelly [**45**, p. 145].

This supplements Mac Enery's letter printed above and shows that his intention to write an account had progressed a long way. How far one cannot say, for Mac Enery habitually understated his work.

Octavian Blewitt. *The Panorama of Torquay*, 2nd Edit., 1832. This contains Mr. Northmore's account of his diggings at Kent's Hole. The relevant matter has been reprinted by Pengelly [**30**, pp. 477/9—495/27]. It is very verbose on the Mithraic Temple, so I have selected the facts from Northmore's two letters. It should be noted that he states that they " were drawn up from some *hasty* memorandums, and I am sorry to add, very imperfect observations made at the time ; reserving a more detailed account, if necessary, for the preface to my own work."

He first notes the prospectus of Mac Enery's *Cavern Researches* circulated about five years since, and regrets non-appearance of the work. This would make the date of the Prospectus as 1827, but it is more likely to be 1828. From his quotations it is clear that he had it before him, though he alters Mac Enery's " British " to " Druidical." Northmore went to Torquay in September, 1824, with the object of proving Kent's Hole to be a " Mithraic temple." By accident he mentioned his purpose to his brother-in-law, Capt. Richard Welby, who lent him Buckland's *Reliquiae Diluvianae*. As a result, on the 21st September, 1824, with two " hired assistants " and " an able draughtsman," he explored the cave " with the double object of discovering organic remains and ascertaining the existence of a temple of Mithras, and happy am I to say that I was successful in both objects ; in the former pursuit I have been followed by hundreds, in the latter by none." Apparently he found about 30 bones and teeth and notes Hyaena, Cave Bear and Wolf or Fox. He at once informed Buckland, who came to Torquay, dug in the same spot and found a British flint knife and bones and teeth, "if I recollect right, of the bear and rhinoceros." He also notes that Trevelyan found "a beautiful tooth of a tiger and a fine jaw-bone of a bear" very near the same spot. He gives a list of the animals found in the cave, including Hippopotamus. He does not state how many times he dug in the cave, but he gives a list of helpers. "My relative, Dr. Greville (the botanist), Admiral Sartorius, Mr. Scudamore, Mr. Barker, the Revd. Mr. M'Enery, Mr. Henderson, Dr. Matthews, the Revd. Mr. Daniel and last though not least the celebrated Professor of Oxford," the last taking an active part in the digging. He also notes "many" of the ladies of Torquay "are in possession of some fine Reliques from this Cavern ; among others Mrs. Edward Cary." This raises the question whether this last may be the "Mrs. C." noted twice in Mac Enery's MS. On the evidence of Mrs. Cazalet's label I feel sure that "Mrs. C." is Mrs. Cazalet. Northmore also states that "Several *British flint knives* were also discovered, one sticking partly in the mud [cave earth] and part in the stalagmite." Northmore apparently also dug at Chudleigh, but alas his work, like Buckland's Vol. II and Mac Enery's *Cavern Researches*, never materialised. We only smile at "Mithraic temple," but in justice to Northmore it must be said that his explanations of the cave, apart from Mithraic temple, are very near to those generally held today.

TWO LETTERS FROM SIR W. C. TREVELYAN TO PROF. W. B. DAWKINS.

Wallington,
Newcastle-on-Tyne,
11th May, 1869.

Dear Sir,

In reading your valuable paper on "Post-glacial Mammals" [32] in the Journal of the Geological Soc. ; as you mention only four specimens of the teeth of *Machairodus latidens* as preserved in this country, it may perhaps interest you to know that I possess a fifth, of which I send you an outline : it was given to me at Torquay, soon after their discovery, by Mrs. Cazalet. The fracture at the point seems I think to be contemporary, and to indicate that it belonged to an old individual.

Should you be in this neighbourhood and would like [to] see it and other bones and teeth which I got when digging in Kent's Hole in 1824 I shall have pleasure in showing them to you if you will favour me with a call.

I remain, Dear Sir,
Yours faithfully,
W. C. Trevelyan.

Boyd Dawkins has cited this letter, but by omitting the commas he has made it appear that Mrs. Cazalet found the teeth [**28**, p. 186].

There is an outline of the tooth on the letter.

Wallington,
26 May, 69.

Dear Sir

Above is a sketch of the tooth and some of its dimensions ; when perfect it must have been, I should think, nearly an inch longer—but the fracture is old and in the crevices of it are traces of the red earth of Kent's hole. I never had any doubt about the truth of the discovery of these teeth in the cave by Mac Enery. Are the bones of the animal sufficiently known to lead to the identification with it of any of those found in Kent's Hole ?

I remain, Dear Sir
Yours faithfully,
W. C. Trevelyan.

The sketch and dimensions are on the letter. This letter shows that Trevelyan thought the teeth came from the Cave Earth. Dr. J. W. Jackson, F.S.A., has most kindly presented these letters to the Geological Survey Museum, and they are now with the specimen which was given to the Museum of Practical Geology by Trevelyan, May 15th, 1871.

SIR W. C. TREVELYAN'S MS.

Extracts from His Diary.

Torquay, 27th Feb., 1826. Saw Mrs. Cazalet's collection of bones from Kents Hole. Very fine, Bear, Tiger [12] Wolf, Hyaena, Elk, Ox, Horse, Elephant, Rhinoceros, Flint Knives. Mr. MacEnery's bones. Very fine horse and Rhinoceros numerous, Roman coins [13].

28th. Spent 7 hours in Kent's Hole with four men, and found bones and teeth of Bear, Tiger, Rhinoceros, Elephant, Hyaena, Horse, Deer, Elk and Flint Knives under Tufa ; i.e., stalagmite from the side or wall of Cavern.

These two extracts were published by Pengelly [**45**, pp. 145-146] and are of great importance. Since Mrs. Cazalet had already given the fine series to the Geological Society she must indeed have had a very large share of what had been found. Trevelyan has probably made a mistake over the original locus of the Roman coins. There is no mention in Mac Enery's MS. of Roman coins from Kent's Hole. They may have come from the cave at Berry Head, but the MS. relating to this has not survived. Pengelly states : " doubtless found in Ansteys Cove " [**45**, p. 170], but Mac Enery only records two from that site [Vivian, **22**. Octavo edition, p. 72, quarto, p. 23].

SCHARF'S BILL FOR THE PLATES.

I am indebted to the late Sir Arthur and Lady Smith Woodward for a copy of G. Scharf's bill for drawing eighteen of the plates. It had been inserted in F. T. Buckland's copy of Vivian's *Cavern Researches*. Professor Buckland died in 1856 and the work was published in 1859, so it was probably put in by the original owner. The bill, which is endorsed on the back by Buckland : " Scharf's Bill. April 1828," is as follows :—

> Drawings made from Nature on stone of fossil bones, etc., found in Kent's Hole, near Torquay, Devon, for the Rev. D. Buckland and the Rev. Mr. Mc Enery.

1827.					
May.	A skull and jaws of Hyaena's	7	0	0	[B]
June.	A skull of a wolf	4	0	0	[G]
do.	Upper jaws or a Palate of an elk	2	0	0	[I]
do.	Horns of an elk	3	0	0	[H]
do.	Lower jaws of Elks, Horse, etc.	4	0	0	[K]
July.	Hyaena's jaws, Elephant's teeth, etc.	4	0	0	[M]
do.	Part of a Rhinoceros's skull, teeth, etc.	4	0	0	[L]
August.	Bear jaws and teeth	3	10	0	[D]
do.	Tyger and Hyaena's jaws	3	10	0	[C]
Sept.	Bears—Hyaena's teeth, several small young	4	0	0	[E]
	10 plates	38	10	0	
Aug. 14.	Received from Mr. Murray on Dr. Buckland's account	10	0	0	
Oct. 28.	Received from Mr. Phillips on account	10	0	0	
Nov. 24.	Received from Mr. Murray for Dr. Buckland	20	0	0	
1827.					
Nov.	Added an under jaw to the Elk's palate	1	5	0	[I]
Dec.	Arrowheads and hatchets of flint and chert from Torquay	3	0	0	[T]
do.	Bones—toes of Bear, Hyaena, etc.	4	0	0	[O]
1828.					
Jan.	Flints and Obsidian from Stone Henge and Mexico	4	0	0	[U]
do.	*Album grecum* and diseased bones	4	0	0	[S]
do.	Gnawed bones	4	0	0	[R]
Feb.	Reduced large bones of Rhinoceros—Ox	5	0	0	[P]
March	Reduced large Bear's bones	4	0	0	[N]
do.	do. of Rhinoceros	3	10	0	[Q]

The letters in square brackets are those on the plates; O and U were not published by Vivian.

IX. BIBLIOGRAPHY.

No attempt has been made to give a full bibliography. That would have taken years of research into the geological literature of all countries and the greater part would be of no use to the student, but I have tried to get a full list of the really important books and papers.

1. 1823, BUCKLAND, W. *Reliquiae Diluvianae* The publication of this book marks the real beginning of English Pleistocene Geology.

2. 1825. April. ANON. "Organic Remains in Kent's Hole and Chudleigh Cave." *The Monthly Magazine or British Register*, vol. lix, pp. 190-1. A short account of digs by Buckland and it is stated that he found a flint knife. This is the earliest record of a human artifact from any cave. The author is T. Northmore. [**9**, p. 194].

3. 1826. April. ANON. "Professor Buckland's notice of the Hyaena's Den near Torquay." *Edinburgh Phil. Journ.*, vol. xiv, pp. 362-4 [see p. for details]. Probably edited by Prof. J. Jameson, but based entirely on a letter from Buckland.

4. 1827. "Annual Report of the Council of the Yorks. Phil. Soc. for 1826." Read at the Annual Meeting Feb. 6th, 1827, and printed later in the same year. On p. 13 is an account of Mac Enery's gift of specimens to the Society, a most important piece of evidence [see pp. 200-203].

5. 1829. DE LA BECHE, H. T. "On the Geology of Tor and Babbacombe Bays, Devon." Read Nov. 16th, 1827. *Trans. Geol. Soc. Lond.*,

Series II, vol. iii, p. 166. Notes the presence of extinct mammals in Kent's Cavern and in a footnote that Mc Enery intends to publish an account of them. Mac Enery has stated that he attended De la Beche in his survey [**31**, p. 402/260.]

6. 1830. Turtin, W., and Kingston, J. F. "The Natural History of the District, etc.," being Part II of *The Teignmouth Dawlish and Torquay Guide*. A very rare book, and is unpaged and undated on the title page, the date being on the spine, hence the trouble as to the correct date. The book is clearly of composite origin with several contributors. There is a brief account of Kent's Hole, with a list of the animals found and the editor states: "We are looking forward with great interest to the publication of a work that has been announced by a gentleman of Torquay, which will contain an account of the treasures that have been unearthed."

7. 1832. Blewitt, Octavius. *The Panorama of Torquay*, 2nd edit. A very rare book. It contains a description of the cave and two letters from T. Northmore, giving full particulars of his work [see pp. 204-5]. Part of the topographical map is printed in colours as a geological map based on De la Beche's survey [**5**]; the earliest geological map in any local guide that I have seen. Northmore's hand can be detected in many parts of the work.

8. 1833-4. Schmerling, P. C. *Recherches sur les ossemens Fossiles de'couverts dans les Cavernes de la Province de Liége*. 2 vols. and atlas of plates. An excellent work, and though the facts were fiercely contested at the time its accuracy is now recognised.

9. 1839-64. Blainville, H. M. D. de. *Ostéographie. Canis, Felis, Hyaena Subursus*. Figures and descriptions of bones found by Mac Enery.

10. 1839. J. C. Bellamy. *The Natural History of South Devon*. Plymouth, pp. 1-455 and 18 plates, mostly of fossils, including six of Pleistocene bones and teeth found by the author at Yealm Bridge. There is a long discussion as to the relative age of the human artifacts and the associated mammals and a letter from Mc Enery is printed, who states his opinion that at Kent's Hole the two series were not contemporary [pp. 94-101]. It would appear, however, that some people were of opinion that Mac Enery knew that they were of the same age and that it was loyalty to Buckland that made him take the opposite view.

11. 1839. De la Beche, H. T. "Report on the Geology of Cornwall, Devon and West Somerset." Brief account of the cave and its contents, and states that "Mr. Mc Enery proposed at one time to give a detailed account, but we believe his intentions were not carried into effect." [pp. 413-4].

12. 1840. Austen, R. A. C. "On the bone caves of Devonshire." *Proc. Geol. Soc. Lond.*, vol. iii, pp. 286-7. Summary, but no mention of bones nor flints [see **13**].

13. 1842. Austen, R. A. C. "On the Geology of the South-east of Devonshire." *Trans. Geol. Soc. Lond.*, Series II, vol. vi, pp. 433-489. His previous paper [**12**] with amplification is included. He states: "Human remains and works of art such as arrowheads and knives of flint occur in all parts of the cave and throughout the entire thickness of the clay, and no distinction founded on condition, distribution or relative position can be observed, whereby the human can be separated from the other reliquae." [p. 444]. The statement that "human remains" were found was an error and the author admitted this to Pengelly. [30, p. 502/34].

14. 1843. Owen, R. "Report on the British Mammalia, Part I." *Brit Assoc. Report* for 1842, p. 68. Describes *Machairodus* from Kent's Hole.

15. 1844-1846. Owen, R. *A History of British Fossil Mammals and Birds.* Many figures and descriptions of specimens from Kent's Hole. Marred by obvious signs of haste and the account of *Machairodus* is self-contradictory. In his preface he thanks Buckland for sending "drawings and unpublished proof impressions" of Kent's Hole specimens.

16. 1847. Vivian, E. "On Kent's Cavern near Torquay." *Quart. Journ. Geol. Soc.*, vol. iii, p. 353. A suppressed paper. It was dismissed with the remark, "In this paper an account was given of some recent researches in that cavern by a committee of the Torquay Nat. Hist. Soc. during which the bones of various extinct species of animals were found in several situations." Vivian states: "A paper which I wrote on the subject was read before the Geological Society, but was considered so heterodox that its insertion in the *Transactions* was delayed until the late lamented Dr. Buckland could again visit the cavern which he was never able to accomplish." [**22**, octavo edit., p. 60 note]. It is difficult to understand this, for the Society had already published identical views by Austen [**13**]. That Dr. Buckland, who was strongly opposed to the greater antiquity of man should be the umpire is humorous.

17. 1847. Vivian, E. "Extract of a letter from Mr. E. Vivian of Torquay, respecting the phenomena of Kent's Cavern" *Rep. Brit. Assoc.* for 1846. Trans. of Sections, p. 73.

18. 1848. April 12th. Anon., probably E. Vivian. *Torquay and Tor Directory* [see p. —]. The first published statement that Mac Enery's MSS. existed.

19. 1850. Mantell, G. A. "On the remains of Man and Works of Art Imbedded in Rocks and Strata." *Arch. Journal*, vol. vii, pp. 340-1. Deals with Kent's Hole and is best forgotten. One wonders how a great geologist could have written such nonsense.

20. 1857. Vivian, E. "Researches in Kent's Cavern, with the original MS. Memoir of its first opening by the late Rev. J. Mac Enery." *Rep. Brit. Assoc.* for 1856. Trans. of Sections, p. 79.

21. 1857. Vivian, E. "The earliest traces of human remains in Kent's Cavern." *op. cit.*, p. 177.

22. 1859. Vivian, E. *Cavern Researches Edited from the original manuscript notes of the late Rev. J. Mac Enery.* There are two issues of this book. Quarto text, pp. 1-25, in double columns and seventeen plates, octavo text, pp 1-78 in single columns and without plates. There is a copy of the Octavo Edit. in the library of the Geological Survey with the plates (*ex. lib.* Murchison). Preface dated Jan. 1st, 1859. Reviewed in the *Athenæum* April 30th, 1859, pp. 574-6. The review is very good and has been reprinted by Pengelly [**45**, pp. 146-7].

23. 1861. Kenrick, J. "The Rev. Mr. M'Enery's researches in the Bone Cave of Kent's Hole, Torquay, etc." *Proc. Geol. and Poly. Soc. of the West Riding of Yorks*, vol. iv., pp. 150-165. A good summary, with additional facts as to Northmore's digs. Contrasts Mac Enery's views with those of Austen [**13**]. States "an eminent geologist who knew him well says M'Enery had no doubt whatever as to the occurrence of flint implements in the lower accumulation with the extinct mammals; this I know from repeated conversations with him. But Buckland would never hear of it: hence the confusion in his views when he came to write his account of the cave and its contents." For confirmation of this see **10**. Partly reprinted by Pengelly, who adds that he had been unable to ascertain who was the "eminent geologist."

24. 1862. Pengelly, W. Letter on the accumulation of Cave deposits. *Geologist*, vol. iv., p. 65.

25. 1864. Blake, C. C. "On the human remains from Kent's Hole near Torquay." *Anthrop. Review*, vol. ii., pp. cclxiii-v. Describes the bones and concludes, "no antiquity can be assigned to the remains."

26. 1866. Pengelly, W. "Report on the Exploration of Kent's Cavern." *Proc. Roy. Inst.*, vol. iv, p. 534.

27. 1867-9. Gervais, F. L. P. "Zoologie et Paléontologié generales."

28. 1868. Dawkins, W. B. and Sanford, W. A. Brit. Pleist. Mammalia, vol. i, pp. 184-192. *Mon. Palaeont. Soc.* A full account of *Machairodus*, but there are errors. They use *Machaerodus*, the illegal emendation of Agassiz 1846, *Machairodus* is 1833.

29. 1868. Falconer, H. *Palaeontological Memoirs*, 2 vols. Many references to and descriptions of specimens. A critical account of *Drepanodon* (i.e., *Machairodus*) based on Owen **[15]** and a personal examination of four of the canines [vol. ii, pp. 459-461]. These notes must have been written before 1859, for he does not mention Vivian's book **[22]**.

30. 1868. Pengelly, W. "The literature of Kent's Cavern, Pt. I." *Trans. Devon. Assoc.*, vol. i, pp. 469-522. The first of an invaluable series which must be consulted by any student.

31. 1869. Pengelly, W. "The literature of Kent's Cavern, Pt. II." *Trans. Devon. Assoc.*, vol. iii, pp. 191-482. This includes Mac Enery's MSS. in full with copious notes. The reprints of Pengelly's early papers were repaged in this case, pp. 1-310.

32. 1869. Dawkins, W. B. "On the Distribution of the British Post-glacial Mammals." *Quart. Journ. Geol. Soc.*, vol. xxv, pp. 192-217. List of the mammals from Kent's Hole, states that the incisor of *Machairodus* figured by Owen is lost and gives a summary of the English examples of the teeth known to him, but overlooks Trevelyan's specimen. [See p. 191.]

33. 1869. Lankester, E. R. "On the occurrence of *Machairodus* in the Forest Bed of Norfolk." *Geol. Mag.*, vol. vi, pp. 440-1.

34. 1869. Pengelly, W. "On the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Cavern." *Trans. Devon Assoc.*, vol. iii., pp. 483-494. He doubts the first, but gives a very full account of the latter.

35. 1869, Oct. Dawkins, W. B. "Kent's Hole." *Popular Science Review*, pp. 369-377. A good summary.

36. 1870. Pengelly, W. "The Ancient Cave-men of Devonshire," unpaged [pp. 1-32]. A summary. It is the report of a lecture and from the setting is a reprint from a newspaper, but there is no clue as to when and where the lecture was delivered.

37. 1871. Pengelly, W. "The literature of Kent's Cavern, Part III." *Trans. Devon Assoc.*, vol. iv, pp. 467-490. Reprints 25 and furnishes the clue as to the origin of the bones partly taken from Blewitt [7].

38. 1872. Evans, J. *The Ancient Stone Implements, etc., of Great Britain*, pp. 442-466. An excellent account of the Cave and its contents, with figures of human artifacts found by Pengelly. The woodcuts make the book a "collector's" book, and copies of this edition always fetch more than the 2nd [56].

39. 1872. Pengelly, W. "Notes on the *Machairodus latidens* found by the Rev. J. Mac Enery in Kent's Cavern." *Trans. Devon Assoc.*, vol. v, pp. 165-179. A full account of the teeth. He concludes that all the teeth came from the cave earth.

40. 1873. Lyell, Charles. *The Antiquity of Man*, 4th Ed. Figures the incisor of *Machairodus* found by Pengelly. [p. 105, figg. 10a, b, c.].

41. 1874. Dawkins, W. B. "Cave Hunting." Summary, figures one canine and two incisors of *Machairodus* [pp. 324-335].

42. 1875. Pengelly, W. "On a tooth of *Machairodus latidens* in the Albert Memorial Museum, Exeter." *Trans. Devon Assoc.*, vol. vii, pp. 247-260. A full account of the incisor at Exeter and concludes that it is the original of Owen's figure. I do not think so.

43. 1877. Dawkins, W. B. "On the Mammal-fauna of the Caves of Creswell Crags." *Quart. Journ. Geol. Soc.*, vol. xxxiii, pp. 589-612. Figure and description of an upper canine of *Machairodus* found by the author in Robin Hood's Cave [pp. 594-5].

44. 1877. Pennington, R. "Notes on the barrows and bone caves of Derbyshire." Many references to Kent's Hole.

45. 1878. Pengelly, W. "The Literature of Kent's Cavern, Pt. IV." *Trans. Devon Assoc.*, vol. x, pp. 141-181. A criticism of popular works pointing out errors.

46. 1879. Adams, A. L. "British Fossil Elephants" (*Palaeont. Soc.*), p. 92, pl. xiii, fig. 2. Tooth of *E. primigenius* figured and described.

47. 1879. Heath, T. *An abstract Description and History of the Bone Caves of the Creswell Crags.* Derby. Octavo, pp. 1-17. A rare pamphlet challenging the bona fides of the *Machairodus* tooth.

48. 1880. Heath, T. *Cresswell Caves v. Professor Boyd Dawkins.* Derby. Octavo, pp. 1-40. A rare pamphlet. On the cover said to be "second edition." The "first edition" is 47. It is not pleasant reading, but the author's statements as to the *Machairodus* tooth and the incised carving of a horse have never been controverted.

49. 1881. Pengelly, W. "Notes on recent notices of the Geology and Palaeontology of Devonshire." *Trans. Devon Assoc.*, vol. xiii, pp. 359-402. Summary of the evidence and criticisms of Murray's *Handbook to Devonshire* and J. Geikie's *Prehistoric Europe.* On p. 387, suggests Northmore was the author of 2. I quite agree.

50. 1882. Newton, E. T. "The Vertebrata of the Forest Bed series of Norfolk and Suffolk." *Mem. Geol. Survey.* Figures and descriptions of remains of *Machairodus*, pp. 21-24, pl. IV., Figs. 4, 5, 5a.

51. 1884. Pengelly, W. "The literature of Kent's Cavern, Pt. V." *Trans. Devon Assoc.*, vol. xvi, pp. 189-434. A resumé of the sixteen annual reports presented to the British Association 1865-1880, describing his work and its results. They are revised and additional matter given. Hence these reports are not given here.

52. 1884. Pengelly, W. "Kent's Cavern and Glacial or Preglacial Man." *Trans. Devon. Assoc.*, vol. xvi, p. 480.

53. 1885-7. Lydekker, R. *Cat. Foss. Mamm. in British Museum* (Nat. Hist.), 5 vols. Vols. 1 and 2, 1885, Vols. 3 and 4, 188, Vol. 5, 1887. Many descriptions of bones from Kent's Hole. Since there is no locality index, search has to be made.

54. 1886. Backhouse, J., and Lydekker, R. "On a mandible of *Machairodus* from the Forest Bed." *Quart. Journ. Geol. Soc.*, vol. lxii, pp. 309-312, pl. x. The specimen came from Kessingland and is now in Dublin.

55. 1894. Gordon, E. O. *The Life and Correspondence of W. Buckland.* There is no mention of either Kent's Hole nor Mac Enery.

56. 1897. Evans, J. *The Ancient Stone Implements, etc., of Great Britain*, 2nd Ed., pp. 488-511. Mainly a reprint of 38, but there is additional matter based on Pengelly's later work. An Abbevillian flint implement from the Breccia is figured [p. 495, Fig. 388a].

57. 1897. Pengelly, Hester. *A memoir of W. Pengelly.* A storehouse of memories of the older geologists and a most readable book. Many references to Mac Enery and his work. Prof. J. G. Bonney gives an account of Kent's Hole.

58. 1898. HUNT, A. R. "A short account of Kent's Cavern." A very good summary. Presented by the Torquay Nat. Hist. Soc. to the members of the British Association visiting Torquay September, 1898. The meeting was held at Bristol.

59. 1900. WOODWARD, H. B., HUNT, A. R. and USSHER, W. A. E. "Excursion to Newton Abbot, Chudleigh, Dartmoor and Torquay." *Proc. Geol. Assoc.*, vol. xvi, pp. 425-442. A good summary, pp. 435-8, plan p. 437. This is the first published plan and was also in the circular.

60. 1901. BOULE, M. "Rev. espec. Europ. de *Machairodus*." *Bull. Soc. Geol. France*, pp. 551-572. A good revision.

61. 1902. BLAKE, J. F. and SHERBORN, C. D. "List of the Types and figured specimens in the Coll. of the Geol. Soc. Lond.," pp. 22-3. List of specimens figured in Vivian **[22]**. A rare and overlooked work. Sherborn always claimed that he did all the work.

62. 1902. HUNT, A. R. "On Kent's Cavern with reference to Buckland and his detractors." *Geol. Mag*, vol. ix, pp. 114-118. An able attempt to defend Buckland against the charge of suppressing evidence, but more evidence on this point is given in this address.

63. 1903. USSHER, W. A. E. "The Geology of the Country around Torquay." *Sheet Memoir Geol. Survey* 350. A good resumé.

64. 1904. *The History of the Collection contained in the Natural History Departments of the British Museum*, vol. i.

65. 1906. BOULE, M. "Les Grand Chats des Caverns." *Ann. de Palaeont.* Tome 1, pp. 69-95.

66. 1909. REYNOLDS, S. H. "Brit. Pleist. Mamm." (*Mon. Palaeont. Soc.*), vol. ii, pt. iii, *Canidae* pt. IV, *Mustelidae*. Specimens from the cave figured and described.

67. 1911. SMITH, R. A. "A guide to the Antiquities of the Stone Age in the Department of British and Mediaeval Antiquities," pp. 65-68. A good summary.

68. 1913. DUCKWORTH, W. L. H. "Notes on some points connected with the Excavation of Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. i, p. 211.

69. 1914. HUNT, A. R. "Kent's Cavern, some doubts and difficulties." *Trans. Torquay Nat. Hist. Soc.*, vol. i, p. 267. These commonly occur with cave work.

70. 1915. KEITH, A. *The Antiquity of Man*, 2nd edition 1920. Several references to the cave, with a description and figure of the right half of a human palate found by Pengelly [pp. 95-98].

71. 1916. LOWE, H. J. "Stone implements from the Breccia of Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. ii, p. 80.

72. 1920. LOWE, H. J. "The needles of Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. ii, p. 325.

73. 1925. GARROD, D. A. E. "The lowest deposit of Kent's Cavern ; a breccia with Chellean Tools and remains of Cave Bear." *Bull. Soc. Prehist. France*. Not seen.

74. 1926. LOWE, H. J. "Ice Age theories and Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. iv, p. 295.

75. 1926. GARROD, D. A. E. *The Upper Palaeolithic Age in Britain*, Oxford. The artifacts from Kent's Hole described and many figured and part of the plan reproduced [pp. 24-47]. The authoress was unaware that all the flints figured by Vivian were in the Geological Survey Museum.

76. 1926. KEITH, A. "Report on a human skull found near the North Entrance to Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. iv., pp. 289-294. Also issued as a pamphlet pp. 1-6.

77. 1926. HINTON, M. A. C. "Monograph of the Voles and Lemmings." (*Microtinae*), vol. i. *Pitymys gregaloides* Hinton, figured [p. 127.]

78. 1927. KEITH, A. "Report on a fragment of a human jaw found in Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. v, pl. 1.

79. 1928. DOWIE, H. G. "Note on recent excavations in Kent's Cavern, Torquay." *Proc. Prehist. Soc., E. Anglia*, vol. v, pp. 306-7. Summary of results of the dig by the Torquay Nat. Hist. Soc. 1926-8.

80. 1929. BEYNON, F., DOWIE, H. G. and OGILVIE, A. H. "Report on the excavations in Kent's Cavern." *Trans. Torquay Nat. Hist. Soc.*, vol. v, p. 237.

81. 1932. DOWIE, H. G. *The History of Kent's Cavern.* Octavo, Torquay. Unpaged, but good photos of the interior and a plan. A very good summary with a criticism of Miss Garrod's view [75].

82. 1933. LLOYD, W. "The Geology of the Country around Torquay." 2nd. Ed. of 63. *Sheet Memoir Geol. Survey* 350. A good summary, plan on p. 127.

83. 1937. JACKSON, J. W. "Schedule of Cave finds." *Caves and Caving*, vol. i, pt. 1, pp. 19-20. This gives the results of a circular sent to all Museums asking for an account of what material they had. More work of this kind is wanted.

84. 1939. BREUIL, H., "Le Vrai Noveau de l'Industrie Abbevillienne." *L'Anthropologie*, Tome 49, pp. 13-34. Records *Machairodus latidens* from the bottom bed, pp. 21-2.

85. 1943. MELMORE, S. "Letters in the possession of the Yorkshire Philosophical Society." *The North Western Naturalist*, pp. 148-160. Mac Enery's letter to the President dated May 3rd, 1826, that was sent with specimens and casts to the Society, reprinted.

SOME WAR-TIME EXPOSURES IN LONDON OF WOOLWICH BEDS AND LONDON CLAY.

By ARTHUR WRIGLEY

[*Received 29th December*, 1944.]

DURING 1941-2 some deep air-raid shelters were constructed in London by forming new tunnels adjoining tube railway stations. By the kind permission of Mr. J. C. Martin, Engineer-in-charge of the Home Office Tunnel Shelter Works for the London Passenger Transport Board, it was possible to examine these excavations and the dumps of material extracted from them. The staff of engineers superintending the work gave great assistance by communicating exact data of levels, so that by their aid it is possible to present some accurate stratigraphical records for a region where new, deep excavations were not anticipated.

Material from the northern group of shelters was dumped in Regent's Park, where the level of part of the playing field south-west of the Zoological Gardens has been raised by a mixture of Woolwich beds and London Clay and surfaced by debris from bombed buildings. On the southern side of the Thames, large mounds of London Clay, from various sites, were dumped behind No. 400 Clapham Road and at the southern and northern ends of Clapham Common, the latter place having an admixture of Woolwich beds from Kennington.

Holborn (Chancery Lane Station). Below Holborn, from Fetter Lane, a tunnel 800 feet long, rising westwards 1 in 60, extends to 100 feet east of Southampton Buildings, where the junction between stiff, grey London Clay and mottled clay of the Woolwich beds is at —36 feet O.D.[1] At Fetter Lane the base of the Woolwich mottled clay (underlain by Woolwich Sands) is at —48 feet O.D. Between these two points, part of the tunnel was wholly in London Clay, so there must be a minor fold here.

Tottenham Court Road (Goodge Street Station). Below the sides of Tottenham Court Road there are two new tunnels 1,300 feet long, from Windmill Street to north of Pancras Street, with shafts and entry tunnels in Chenies Street and Whitfield Gardens. Three preliminary boreholes were made, with records and samples preserved, which I have seen. The tunnels are wholly in the Woolwich beds and, combining their sections with those of the boreholes, we have here, in descending order :—

Base of stiff, grey London Clay at + 17.5 feet O.D. (i.e. 74.5 feet below the road level of + 92 feet O.D.).

Woolwich Beds.

Mottled Clay, green and purplish-red, with some grey clay and thin lignitic seams in the centre ... 33 feet

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[1] The — and + signs indicate levels below and above Ordnance Datum.

Soft, yellow sand with a 6-inch layer of black flint pebbles at the base	21 feet
Thanet Sand	
Grey sand, pierced for	14 feet

In the tunnels, the yellow sand rises at Chenies Street and Whitfield Gardens, with only the overlying mottled clay seen between these two points. At one place in the mottled clay was a 4-inch band of calcareous stone with rounded, pebbly inclusions of mottled clay. The only Woolwich-bed fossils noticed were a few poorly-preserved "*Cyrena*" from the grey clay with lignite. When freshly cut, the mottled clays in the sides of the tunnels showed remarkably bright colours which, with the marks left by power-driven hand spades, gave the effect of a modernist painting of a rather advanced type. The workmen here and elsewhere called the mottled clay *plaid*, evidently thinking that it looked like a tartan. Those who only know our Eocene sediments in superficial exposures would be surprised by their vivid colours underground, before they have been exposed to the air. The Woolwich bottom-bed, for example, where it is very glauconitic, is of a dark but bright bottle-green, which quickly fades to dull grey in a heap of the material left on the surface of the ground.

This record supplements the printed accounts of the well-known boring at Meux's Brewery[1] in Tottenham Court Road, a little south of the present exposure. Whitaker, 1889, p. 168, was forced to say that the boundary of the London Clay and Woolwich beds was left very uncertain by the well-sinker's records.

Camden Town and Belsize Park stations. Here, the excavations were wholly in stiff, grey London Clay. The material from these places dumped in Regent's Park, together with some London Clay from Chancery Lane and Goodge Street stations, was uniformly almost unfossiliferous and no trace was noted of any sandy, pebbly or shelly basement-bed. A notable absence of iron pyrites may be associated with a lack of organisms. The London Clay fossils found upon the Regent's Park dump were :—

Terebratulina wardenensis Elliott
Nuculana partimstriata (Wood).
Arca (*Trigonodesma*) *impolita* J. de C. Sby.
Aequipecten duplicatus (J. de C. Sby.).
Teredo sp.
Dentalium anceps J. de C. Sby.
Odontaspis macrota (Ag.).

All these were exceedingly rare in proportion to the large amount of clay examined : they are species which are confined to the lower half of the London Clay.

The Oval Station, Kennington. In a shaft in the triangle by Kennington Church, where the surface is at + 16 feet O.D., the base of the stiff, grey London Clay was 74 feet down, at —58 feet O.D. Descending below this level were :—

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[1] Now the Dominion Cinema-Theatre.

Woolwich Beds

Sandy, blue clay without pebbles or fossils —4 feet 9 inches
Black, sandy clay with mollusca and flint pebbles up to 3 inches long : a 9-inch seam of "*Paludina*" stone at —70 feet O.D. 12 feet 3 inches
Dry mottled clay, whose top is at —75 feet O.D.

At No. 4, Clapham Road, another shaft passed the base of the London Clay at —53.5 feet O.D. Below this were 17 feet of Woolwich beds—black, sandy clays with flint pebbles and mollusca and a 2-inch stone bed full of "*Cyrena*" and "*Melania*," all resting at —70.5 feet O.D. on mottled clay.

The local engineer-in-charge communicated a record of a trial borehole made in 1924 in Kennington Park, where the base of the London Clay was found at —53.5 feet O.D. resting on 16 feet of dark, sandy clays of the Woolwich beds with shells and pebbles, which were underlain by 9 feet of white sand instead of mottled clay. These records show that the base of the London Clay begins to rise from Kennington Church, along Clapham Road.

All the material from Kennington was dumped at the north end of Clapham Common, where Woolwich beds were seen in some quantity and the following fossils from them noted :—

Fossils of the Woolwich beds near Kennington Church
(C—common, R—rare)

R. *Nucula fragilis* Desh.
R. *N.* sp. (much longer than the preceding).
C. *Ostrea* sp., very poorly preserved.
C. [*Cyrena*] *Corbicula cuneiformis* (J. Sby.); form *forbesi* Desh
R. *Theodoxus subornatus* (d'Orb.) with colour markings.
C. [*Paludina*] *Viviparus* sp. as internal casts in a concretionary stone.
C. "*Melania*" *inquinata* (Defr.).
C. *Tympanotonus funatus* (Mant.).
R. *Murex abbatiae* Wrig.
Planorbis hemistoma J. Sby. : a minute species.
R. *Planorbis* sp. Nothing like it is recorded from the Woolwich beds, for it was as large as a shilling : unhappily it fell to powder in an attempt to remove it.

Stations at Stockwell, Clapham North, Clapham Common and Clapham South. The shelters near these stations were all cut in London Clay at a depth of about 90 feet, but no exact measurements were obtained. The spoil was dumped at the north and south ends of Clapham Common and behind 400 Clapham Road and was examined there. The clay was so very sparsely fossiliferous that specimens were obtained only by a thorough search of well-weathered material. At Clapham South Station were many pale-grey, flat concretions ("cheeses") which characterise the lowest London Clay of South London.

Fossils of the London Clay between Stockwell and Clapham South Stations.

CORALS

- R. *Graphularia wetherelli* M. Edw.

CRINOIDS

- R. *Balanocrinus sub-basaltiformis* (Mill.)—columnals: indicates Division 2.
- R. *Isocrinus oakeshottianus* (Forbes) [? = *tintinnabulum* Forbes] columnals: indicates Division 3.
- R. *Antedon* n. sp.[1] A pyritised crown showing brachial characters which resemble those of the living *A. basicurva* Carp. With this may be associated some isolated brachials and a centrodorsal found by A. G. Davis, 1928, in the London Clay from the tube railway in this district.

MOLLUSCA

- R. *Nucula ? bowerbanki* J. de C. Sby.
- R. *Nuculana partimstriata* (Wood).
- R. *N. amygdaloides* (J. de C. Sby.).
- R. *Pteria papyracea* (J. de C. Sby.).
- C. *Aequipecten duplicatus* (J. de C. Sby.).
- C. *Dentalium anceps* J. de C. Sby.
- R. *Orthochetus elongatus* Wrig.
- R. *Aporrhais sowerbyi* (Mant.).
- C. *Euspira glaucinoides* (J. Sby.).
- R. *Ficus londini* Wrig.
- R. *Pseudoneptunea curta* (J. Sby.).
- *Surculites errans* Sol. [*bifaciatus* Sby.]
- R. *Turricula helix* (Edw.).
- R. *Tornatellaea* aff. *simulata* (Sol.).
- R. *Scaphella wetherelli* (J. de C. Sby.).

CRUSTACEA (determined by Mr. Withers)

- *Xanthopsis nodosa* M'Coy.
- *Dromilites bucklandi* M. Edw.

These fossils indicate my divisions 2 and 3 of the London Clay, but a large amount of the material seen upon the Clapham dumps was quite unfossiliferous. This accords with the stratigraphical data, which indicate that the shelters were cut in divisions 1 and 2, the shafts at Kennington piercing division 1 and the shafts around Clapham cutting through division 3. (Consult Davis, 1928, pl. 24.)

Mr. D. J. Jenkins obtained several pyritised fruits and seeds from the dump at the south of Clapham Common, where the material was all extracted from the shelter at Clapham South Station and may safely be assigned to division 2 of the London Clay. Miss M. E. J. Chandler has kindly determined the species :—

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[1] I hope to write and illustrate a full account of this and other unpublished London Clay Crinoids when materials for comparison are once more available.

Nipa Burtini (Brongn.).
Wetherellia variabilis Bow.k.
Palaeophytocrene foveolata Reid & Chandler.
Icacinicarya n. sp., which previously has been found only at Herne Bay and may provisionally be regarded as characteristic of division 2 of the London Clay.
Anacardiacae (*Spondieae*) ? genus—a seed only.
Mastixia parva R. & C.
Lanfrancia subglobosa R. & C.
Dunstania multilocularis R. & C.
Carpolithes ? sp. nov.
Bored wood.

Icacinicarya reticulata previously has been found only at Herne Bay and may provisionally be regarded as characteristic of division 2 of the London Clay.

A notable feature of these excavations, both north and south of the Thames, is the absence of any recognisable London Clay basement bed with sandy sediment, flint-pebbles or fossils. Some decidedly sandy clay seen on the Clapham dumps may represent such an horizon, but may equally well be attributed to the sandy seams found in the lowest London Clay of outer South London, e.g. at Handley's brickworks, Woodside.

Mr. A. G. Davis and Mr. D. J. Jenkins have kindly communicated the specimens they found on the Clapham Common dumps.

REFERENCES

Davis, A. G. 1928. *Proc. Geol. Assoc.*, vol. xxxix, pp. 339-352, pl. 24.
Whitaker, W. 1889. *Geology of London*, vol. ii.
Wrigley, A. 1940. *Proc. Geol. Assoc.*, vol li, pp. 240-1.

FIELD MEETING AT ELMSTEAD WOODS, KENT.

Saturday, 28th July, 1944.

Report by the Director: Arthur Wrigley.

[*Received 23rd August*, 1945.]

ON this repetition of last year's field meeting at Elmstead Woods, our seventh visit since 1864, there was no distraction of flying bombs and we appreciated the blessing of peace, but not of plenty, for tea was unobtainable. After a glance at the station cutting where the pebbly Blackheath sands overlie the Woolwich bottom-bed at about rail-level, we ascended the high ground of Elmstead Woods above the railway tunnel. Passing a grotto built of stone from the Rock-pit, an extensive view opened from the northern brow of the hill. Standing on the lowest London Clay, we looked down westward over the slope of Blackheath pebbles to the Woolwich beds and Thanet Sands with a small anticlinal inlier of Chalk on the golf course below. Northward, favoured by clear, sunny weather, was a fine view of London, with St. Paul's dome distinctly seen against the dim outline of the Hampstead ridge, on a horizon 14 miles away.

Descending the hill, we soon found the well-known Rock-pit in an enclosed copse hard by the station. Geologists have always called this spot Sundridge Park, for it used to lie within a large estate of that name, but now it seems best to refer it to Elmstead Woods, because the present place and station called Sundridge Park are over a mile away. The fine section of the Rock-pit showed us 20 feet of pebbly sands of the Blackheath beds above an 8 feet talus, and Whitaker records that 15 feet of sand and pebbles have been pierced from the floor of the pit. This total of 43 feet agrees with the 40 feet of Blackheaths observed at the southern end of the neighbouring railway tunnel. The sands were seen to be strongly current bedded, with flint pebbles smaller and sparser than in many other localities. The whole section is crowded with fossils, either whole and very friable, or forming seams of comminuted shells. Only a few species are common, with scattered rarities, and there is a marked contrast with the far more marine fauna which was found in the railway tunnel, perhaps at a slightly lower horizon. This occurrence of the marine, Oldhaven type (tunnel) and the " estuarine " Blackheath type (Rock-pit) in such a limited area, caused Whitaker and Stamp to use both terms in their descriptions of the place. At the top of the section, following the slope of the ground rather than forming a definite horizon, the beds are indurated into a conglomerate of flint pebbles, oyster and " *Cyrena* " shells, which is the " rock " for which the pit was opened. Unconsolidated beds are seen to pass laterally into the conglomerate.

By discussion on the spot we saw that we had before us a striking case of the problem of derivative fossils. The large *Ostrea bellovacina* found here are often bivalve and frequently seen grown to flint pebbles. They could not have travelled far and must have lived in the sea upon a pebbly bottom. This observation on the Rock-pit was clearly made in 1813 by Townsend in his *Character of Moses*, and he adds : " There are many single shells which are worm-eaten or covered by Serpulae." These are the " *Cyrena* " which are so common and which abound in the Woolwich shell-beds below, where they are bivalve. Remembering that the Blackheath beds mark a marine transgression over a lagunar continental margin, it seems highly probable that masses of Woolwich-bed shells were swept into the Blackheath Sea and re-deposited there in these current-bedded sands. Probable derivatives of this kind are marked * in the following list. The previously published faunal lists for " Sundridge Park " combine the Rock-pit and the tunnel[1] into one locality, so it seems desirable to record what we found in the Rock-pit alone, during our visit or in preparation for it.

Fossils of the Blackheath Beds in the Rock-Pit at Elmstead Woods.

A—abundant, C—common, R—rare. Obsolete generic names are within square brackets.

C. *Serpula* sp. grown upon " *Cyrena*."
R. *Discinisca ferroviae* Muir-Wood, a brachiopod found inside bivalve *Ostrea* : although it occurs rarely in the Woolwich Beds, its present situation and its great fragility preclude the idea of derivation.
R. *Nucula fragilis* Desh.
*R. [*Arca*] *Barbatia modioliformis* (Desh.).
[*Pectunculus*] *Glycymeris plumsteadiensis* (J. Sby.).
A. *Ostrea bellovacina* Lam.
*R. *O. tenera* J. Sby., always broken, never bivalve.
*A. [*Cyrena*] *Corbicula cuneiformis* (J. Sby.).
*C. *C. cordata* (Mor.), usually broken.
R. *Phacoides* 2 spp., minute and bivalve.
C. [*Corbulomya*] *Lentidium antiquum* (Desh.), bivalve.
C. [*Corbula*] *Aloidis arnouldi* (Nyst).
R. *A. morrisi* Edw. MS. [=*regulbiensis* var. B Morris].
R. *Theodoxus subornatus* (d'Orb.) with colour markings.
R. *Theodoxus uniplicatus* (J. de C. Sby.).
* " *Hydrobia* " *parkinsoni* Morris
R. *Melanopsis* sp., broken.
*C. " *Melania* " *inquinata* Defr.
*C. *Tympanotonus funatus* (Mant.).
R. *Calyptraea* sp.
R. *Murex abbatiae* Wrig.
R. *Pollia lata* (J. Sby.).
*C. " *Planorbis* " *hemistoma* J. Sby.

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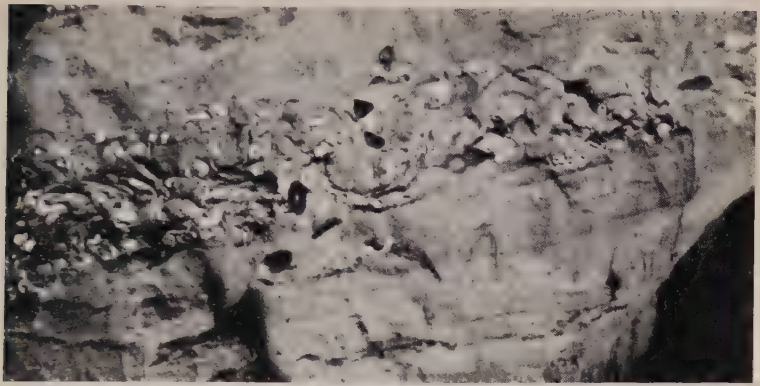
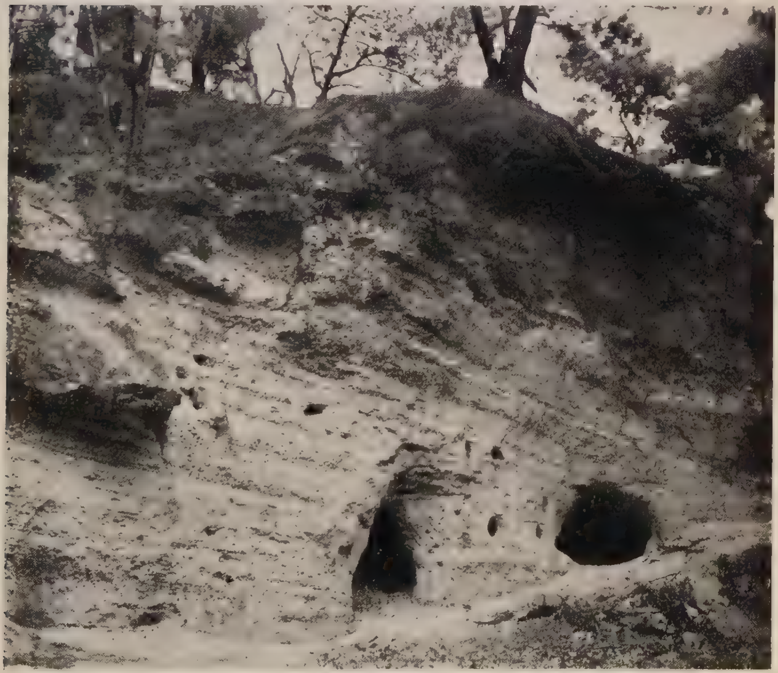
[1] Meyer's collection of fossils from the Elmstead Woods railway tunnel is preserved in the Sedgwick Museum, Cambridge, together with his MS. list of them.



[*Photo: G. Austin Browne.*

A.—BLACKHEATH BEDS, WITH SHELLS AND PEBBLES; ROCK-PIT, ELMSTEAD WOODS.



[*Photo: A. J. Bull.*

B.—FOSSILIFEROUS BLACKHEATH BEDS; ROCK-PIT, ELMSTEAD WOODS.

The decayed condition of the majority of these mollusca, whose shells are of aragonite, is strongly contrasted with the unaltered calcite of the *Ostrea*. One sometimes wonders if the unfossiliferous condition of many exposures of Blackheath beds is due to their decalcification, but were this so the oysters, which always are present among the fossils, would surely have remained.

Mr. H. W. Harrison kindly permitted us to visit the Rock-pit, Dr. Himus was Field Meeting Secretary, and we are indebted to Dr. A. J. Bull and to Mr. G. Austin Browne for the photographs of this noteworthy section, reproduced on plate 9, which give a general impression of the current bedding and the projecting masses of "rock" in the upper part and adds the detail of a 4-inch band of flint pebbles and fossil shells.

REFERENCES

PARKINSON, J. 1811. Organic Remains of a former World, vol. iii, p. 213.

TOWNSEND, J. 1813. *The Character of Moses* established for Veracity as an historian, pp. 251, 257.

BUCKLAND, W. 1817. *Trans. Geol. Soc.*, vol. iv, pp. 277-

MANTELL, G. A. 1844. *Medals of Creation*, vol. i, p. 385.

WHITAKER, W. 1889. *Geology of London*, vol. i, p. 227.

STAMP, L. D. 1920. *Proc. Geol. Assoc.*, vol. xxxi, pp. 151-3, with further references.

FIELD MEETING AT GUILDFORD AND THE GUILDFORD BYPASS.

Saturday, 21st June, 1945.

Report by the Directors: Miss Emily Dix, D.Sc., F.G.S., and Major C. W. Wright, M.A., F.G.S.

[*Received 10th September*, 1945.]

THE first party of members travelled to Guildford by an early train to examine the brickpit of the Sussex and Dorking United Brick Company near Guildford, where Reading Beds and London Clay are exposed. The highly fossiliferous shell-bed in the former yielded abundant specimens of *Cyrena* spp., *Brotia inequinata* Defrance and fragments of *Ostrea bellovacina* Lamarck, while several members found examples of the characteristic fish teeth (*Odontaspis*). Small crystals of selenite, which had formed on the weathered surface, were also examined.

Additional members arrived shortly after 2 o'clock, and the whole party of 30 then walked through the Onslow housing estate to a small chalk-pit in the zone of *Offaster pillula* just south of the eastern end of "Curling Vale." This is the only permanent exposure of the zone in Surrey and has yielded a considerable suite of fossils. The zone fossil and *Actinocamax granulatus* (Blainville), which occur here, were unfortunately not found on this occasion, but members quickly extracted specimens of *Echinocorys scutatus* (Leske), chiefly Brydone's form *depressula*, *Ostrea canaliculata* Sowerby, *O. vesicularis* Lamarck and polyzoa.

Lack of time prevented examination of the now largely overgrown Wilderness pit in the *Marsupites* zone, but its site was pointed out.

Advantage was taken of the magnificent prospects from the Hog's Back ridge to explain on the ground the geology of the district, before the Bypass sections were examined in detail.

The first cutting at the crest of the Hog's Back furnished characteristic fossils, including the zonal index, of the zone of *Micraster coranguinum*. Several small specimens were found of *Gibbithyris ellipsoidalis* Salmi, which is not uncommon here, and a single example of *Aequipecten pexatus* Woods, a rarity at this horizon.

The base of the *Micraster cortestudinarium* zone was next examined south of the crest of the ridge. Specimens of the zone-fossil and of *M. praecursor* Rowe were soon found. The zone of *Holaster planus*, which is well exposed, yielded abundant fossils, including the zone-fossil, *Micraster leskei* Desmarest, *M. corbovis* Forbes several species of *Gibbithyris* and a few molluscs of "Chalk Rock" type, among them a fine *Prioncyclus*. This ammonite, found by Mrs. O. D. Suggate, is not one of the species of the genus recorded for this country and is probably new. Two dip faults and one of the Hog's Back reversed strike faults were pointed out and the structure of the Hog's Back was discussed.

Passing through cuttings, now overgrown, in Gault, Folkestone Sands and Bargate Beds, the party reached Compton, where much-needed tea was enjoyed at the " Coffee House." The return journey was by the Pilgrims' Way, along the outcrop of the Folkestone Sands, first through the woods and then along Sandy Lane into Guildford.

Acknowledgments are due to the manager of the Sussex and Dorking United Brick Company's Brickworks and to Mr. W. P. Robinson, the Surrey County Engineer, for permission to examine the sections.

FIELD MEETING AT BARMING AND EAST MALLING, KENT.

(Weald Research Committee).

Saturday, 29th September, 1945.

Report by the Director : G. W. Himus, Ph.D., F.G.S.

[*Received 19th October*, 1945.]

THE party of 19 met at Barming Station, where the Director gave a short talk on the geology of the area and the programme. A traverse would be made over the dip-slope of the Hythe Beds and across two outliers of Folkestone Sands, which occupy the high ground above the valley of the Medway.

The Hythe Beds consist of alternating bands of grey limestone (" rag ") and calcareous sandstone (" hassock ") with lenticles of chert in the upper part of the succession. The total thickness in the district is from 80 to 100 feet. The Folkestone Sands (of which only the lower 20 or 30 feet are present) are yellow and brown unconsolidated sands, decidedly loamy towards the base. Whether Sandgate Beds are present is a moot point ; that they have been there at one time seems fairly certain, for there are several areas on the map marked " Fullingpits Wood," the surface of which show evidence of extensive excavations, presumably resulting from the working of fuller's earth, which occurs in the Sandgate Beds, and which is worked on a large scale in the neighbourhood of Redhill. There are signs of similar workings in a number of other woods round Maidstone, and there would be an opportunity of seeing the remains of such diggings later in the day.

After the introductory talk, the party moved south along Hermitage Lane, and at Hermitage Farm turned west along a field track through the hop gardens. Here, the Director drew attention to the high ground to the east and south of the farm, which he said is formed by Folkestone Sands ; the more gently sloping area to the north and west, occupied by hop gardens and orchards, consists of Hythe Beds. In general, cultivated ground in the neighbourhood follows the outcrop of the Hythe Beds, while the Folkestone Sands and Sandgate Beds (if present) are usually marked by woodland.

At the old barn, about a furlong west of Hermitage Farm, the party turned south and soon entered Fullingpits Wood, where rather loamy Folkestone Sand was seen in the banks by the track. The ground within the wood was observed to be very irregular, being marked by small pits and hummocks resulting from the working of fuller's earth. Presumably, therefore, Sandgate Beds have been present over this area, but it is now impossible to separate them from the Folkestone Sands, which, geographically, are on the site where they were originally deposited, although they are now largely turned over and mixed as the result of human interference.

After emerging from Fullingpits Wood, a narrow, closely-hedged path was followed southwards across the level ground formed by the Hythe Beds, and near Long Rede an opportunity was taken to obtain a view to the south across the valley of the Medway. From the viewpoint, the ground could be seen sloping fairly sharply to the river, which here runs approximately east-north-east, presumably along the strike of the Hythe Beds. This, however, is not certain, for in the neighbourhood of East Malling the general strike changes from that of West Kent (W.S.W. to E.N.E.) to that of East Kent (W.N.W. to E.S.E.), and although it is known that the change in direction of strike in the Chalk occurs in the Medway gap, the precise direction of the axis about which the change takes place is not known accurately. As far as the eye could reach the view was bounded by high ground formed by the Hythe Beds which, as the Director pointed out, have, in the Maidstone district, a somewhat disconcerting habit of slipping and sliding into any and every valley. The result is that, although the regional dip is no more than 3° to 5°, slightly East of North, dips measured in quarries and road-sections are found to be high (as much as 60°), and *always* into the nearest valley. In consequence, the lower margin of the Hythe Beds is liable to be found much farther down than would be expected from the known thickness of the beds and their regional dip.

Retracing their steps a little, the party next proceeded westwards to the conspicuous water tower on the edge of Ditton Common and, about 70 yards to the south of the tower, turned into the straight ride through Oaken Wood, which runs W.S.W. for about seven furlongs to Seven Wents. Slightly to the north of the ride are two parallel pebbly ridges, consisting of a mass of fragments of chert with little other material. On a recent visit the Director had picked up a well-formed scraper made of flint, which was conspicuous amongst the pieces of chert. Some discussion took place on the question of the origin of the cherty ridges, and Mr. S. C. A. Holmes said that they evidently consisted of "head" and were closely similar to those he described north of Offham. (*Geol. Survey*, "Summary of Progress for the year 1936." Part I, p. 42.)

Continuing westwards through the wood, which consists of chestnut saplings grown for the purpose of making fencing and hurdles, an outlier of Folkestone Sands was noted just to the north of the ride. Here the sands are loamy and very near the base; they bear a growth of oaks, together with a few conifers, so that there is a marked difference between the vegetation and that on the surrounding Hythe Beds.

A second (and larger) outlier of Folkestone Sands extends westwards from the Seven Wents, at which point, seven rides join. For the most part, the Folkestone Sands in this outlier are loamy, but there is a patch of gritty sands towards the western end.

Round the Seven Wents there are a number of well-grown conifers, and hedges of rhododendrons border some of the rides. In this area there has been much trenching and pitting, presumably for the extraction of fuller's earth.

From the Seven Wents the party turned south westwards and made by the shortest route for the Old Cyder House, where lunch was eaten. Fortunately the weather was glorious, and it was possible to sit with comfort on the grass, there being no accommodation for a party under cover.

After lunch a visit was paid to extensive disused workings about half a mile south-east of the Cyder House. Here, a section was seen showing Hythe Beds, consisting as usual of alternating rag and hassock ; there is evidence of much solution in the upper part of the section, the beds being much " tumbled." Lower down, the beds were fractured extensively and were seen to be dipping at about 45° in a direction S. by W., that is, into the valley of the Medway. The Director said that wherever he had been able to find a section in Hythe Beds in which a dip could be measured, that dip was invariably into the nearest valley. The only conclusion he could come to was that the cause was slip of the Hythe Beds over the surface of the Atherfield Clay ; he did not believe that the high dips were the result of folding, because their directions were so consistent with respect to the valleys. Asked whether he had ever observed any reversed dips (that is, *into* the hillsides), the Director said that he had not, and Dr. A. J. Bull remarked that this suggested that the beds had slipped *as a sheet* over the underlying clay and that it was not an example of slipping of the hillside.

After leaving the pit the party proceeded to West Lodge, Barham Court, and inspected the dry valley which descends from near the North Pole Inn to the Medway, which it joins close to the lodge at the south-east corner of the grounds of the court. On the south side of the valley there is a well-marked terrace, which unfortunately was not clearly visible owing to vegetation : the northern flank is covered by a spread of high-level brickearth, which is apparently continuous with that seen at the old brickworks south of West Malling (E.E. S. Brown, Field Meeting at West Malling, Kent. *Proceedings*, xlviii, 1937, p. 396). There is a small exposure in the brickearth on the left side of the deeply trenched lane leading northwards from West Lodge to North Pole Road.

A visit was next paid to a small overgrown pit in Folkestone Sands about 150 yards N.N.E. of the Cyder House. Here, about 10ft. iron-red, current-bedded, gritty quartzose sand was exposed. The sand was capped by gravel,[1] consisting mainly of angular chert, with (perhaps) 5 per cent. of pebbles of flint, almost all well-rounded and generally weathered right through, together with a little ironstone and very occasional rounded pebbles of quartz. The Director stated that about seven years ago, when he first visited the section, there was far less vegetation in the pit, and he found that a sample of the sand, taken towards the northern end, contained about 11 per cent. fine silt and clay, which agreed well with results obtained from other exposures in the main outcrop of the Folkestone Sands. A sample taken lower down, near the entrance to the pit, contained 64 per cent. fine silt and clay, which was consistent with basal Folkestone Sands. North-westwards from the pit were long, sinuous abandoned workings, showing that much of the ground in the neighbourhood must have been turned over in the search for fuller's earth.

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[1] This gravel is mentioned by Topley (" Geology of the Weald " p. 178) as follows :—" The highest patch of gravel observed is at a clump of beech trees by the roadside east of East Melling Heath, due south of East Malling. It contains flints, Tertiary pebbles, chert, decomposed rag and Wealden pebbles. There are some rather large masses of chert lying about ; the dimensions of one of the largest were 12 in. x 8 in. x 9 in. The road a little west of this point is 328 feet above mean sea level, or 303 feet above the river at Wateringbury ; the gravel pit is at a slightly higher level." Although the pit mentioned by Topley cannot now be indentified there is no doubt that he was referring to the same spread of gravel of which a small section was seen during the Field Meeting.

From this point the party walked through woodland paths and across orchards to East Malling, reaching the road at what is locally known as "The Rocks," an appropriate name, for strong ribs of Hythe Beds can be seen from time to time at the side of the road forming the bases of several walls.

After a welcome tea at Turner's Corner House Café, Dr. A. J. Bull proposed a vote of thanks to the Director and to Mr. G. S. Sweeting, who acted as Secretary. This concluded the official business of the Field Meeting.

While waiting for the return train for London, some of the party visited the Ditton quarry in Hythe Beds, while a few walked along the track south of East Malling Church. Thence, a good view northwards was obtained across the Hythe Beds, the surface of which slopes evenly and gently in the direction of Aylesford. To the north-east could be seen the conspicuous tree-covered mound of Holt Hill, which is an outlier of Folkestone Sands, while to the north-west a smaller and less conspicuous outlier stands up slightly south of Ditton.

FIELD MEETING AT PANGBOURNE AND SULHAM.

Saturday, May 5th, 1945.

Director : Prof. H. L. Hawkins, D.Sc., F.R.S., F.G.S.

[*Received 1st September, 1945.*]

THIS field meeting was planned to serve a double purpose—a study of the valley of the lower Pang in relation to past changes in the course of the Kennet, and a detailed correlation between the scenery, vegetation and geology as displayed in Sulham Woods. The former intention was denied fulfilment by the weather, which, murky throughout, provided continuous drizzle with occasional showers. The latter investigation was seriously limited, although the vegetation effectively impressed itself on the members by concentrating the pervading moisture into an especially saturating state.

A party of about twenty members travelled from London, and was augmented at Reading and Pangbourne by local members and friends. After a short visit to the mouth of the Pang, the party moved to the new pumping station of the Reading Corporation Waterworks. Here the new well was already in service and an old one was in process of enlargement. Mr. W. C. Young, assistant to the Waterworks Engineer, gave interesting particulars of the development of the site, and the Director explained the chief geological features concerned. The new boring, made about three years ago, passed through about 20 feet of gravel and peaty loam, and then reached chalk of the *M. cortestudinarium* zone. The *H. planus* chalk below this was very nodular and yielded several typical Micrasters ; and the Chalk Rock (about 50 feet from the surface) was very strongly developed. Below this Terebratulina was abundant at several horizons. The bulk of the water (about $2\frac{3}{4}$ million gallons a day) seems to come from the Chalk Rock. The Director admitted that the yield was much greater than he had dared to forecast when recommending the site ; and that a possible explanation of the great success of the boring was not found until afterwards. Careful levelling of the Chalk Rock at outcrops in the district, and proved in sundry borings, some of which were made after the Pangbourne one, combined with calculations based on other zones accessible and a detailed survey of the Chalk-Reading Beds junction, showed that in the area just south of Pangbourne the slight southerly dip of the strata is temporarily increased. The flexure, though very slight, may have strained open the joints in the Chalk Rock, thus affording easy passage for the water.

Attention was then drawn to the superficial deposits, which have been well displayed by many excavations on the site, and were still visible at several points. The topmost layer of peaty soil with occasional " nests " of shelly marl, proved to be resting on an almost continuous layer of chalk (averaging 6 inches thick), which in turn overlay more black peaty loam. The layer of chalk was, after several abortive speculations, traced to the railway engineers, who, at the time of the excavation of " Shooters' Hill Cutting " just beyond Pangbourne Station, dumped the chalk on the Pang marshes. It is interesting and suggestive to find this chalk, which was put there about a century ago, now buried to a depth of about two feet ; but it would be unsafe, for many reasons, to claim that this gives a measure of the rate of accumulation of the alluvium. However, it is a fact that the peaty soil above the layer of chalk is replete with shards of modern crockery, and that these were not found in the peaty loam beneath. Instead, bones of the red-deer occurred in the lower loam.

The contact of the alluvium and gravel is sharp and fairly even, but the upper part of the gravel is stained locally in a most irregular fashion. Pockets, or perhaps channels, of almost black gravel occur abundantly, extending downwards for at least three feet and sharply marked off from the normal gravel, which is very pale in colour. Apart from its colour (due probably to some stain of organic origin) the gravel in the " pockets " seems continuous with, and similar to, the surrounding mass. This is a well-sorted flint-sarsen gravel, mostly quite fine, though often almost free from sand. By an interesting coincidence the foreman of the contractors, a man of long experience among the gravels of the district, became convinced against his expectation that the gravel was of a type normal in the Kennet valley and wholly unlike that of the Thames. He thus unwittingly supplied independent, but expert, witness in support of the view that the Kennet flowed into the Thames at Pangbourne at no very distant date.

After visiting the pumping house, pleasant in its externals and spotless within, the party proceeded to follow the course of the mains, which take the water to the high level reservoir on Tilehurst Common. The trench, about five feet deep, was carried for about a mile southward (almost to Tidmarsh) and thence across the valley to Sulham. Throughout this distance the filling of the valley proved fairly constant, with the gravel (beneath peaty soil) usually about three feet down and fully charged with water, although the trench was dug at the peak of a period of drought.

As the party crossed the valley, which is about three-quarters of a mile wide, the bold escarpment of Sulham Woods gradually came into clearer view. It was possible to detect the contrast in colour between the beech-trees on the Chalk at the foot of the scarp and the oak-trees and hazel-bushes that cover the clayey slopes above, with a thin dividing line of dark pines and spruces which coincides, with surprising fidelity, with the sandy Reading Basement Beds. The southerly dip could be traced for some distance, but the mist hid the place where the Reading Beds come to the base of the hill, and the beech-trees disappear.

After a short rest, abbreviated by a heavy shower, by the village stocks at Sulham, the party climbed the scarp by the road up which the mains are laid. The Director described the section that had been exposed by the trench. For about the first 100 feet of the rise (roughly 150 O.D. to 250 O.D.) the gradient is gentle, whereas the final 75 feet are quite steep. The gently sloping lower part proved to consist, to a depth certainly greater than five feet, of chalk rubble, with no trace of bedding or sorting, containing large and small blocks of chalk and unworn flints of all sizes. Only at the very top of this slope, just before the gradient increases, was bed-rock chalk touched. This scree-like deposit was pure chalk-detritus, without a trace of contamination by the overlying clays and gravel, and it covered the true chalk almost to the level where that disappeared beneath the Reading Beds. Since these clays, and the gravel that caps the hill, present a confused medley of slumping and hill-creep, it is difficult to account for the purity of the Chalk rubble (over which landslips of clay have ridden in places), unless on the assumption that it was produced at a time when the slippery material was immobilised by drought or freezing. Perhaps it is analogous to the " Combe Rock " of other districts.

The section of the steeper part of the hill was more of the nature of an inside view of slumping than of a stratigraphical succession. Masses of gravel, often still-bedded, had plunged into the softer clays, and these had flowed over the sandier layers until no natural sequence could be discerned. Even the contact between the Reading Beds and Chalk was detected only after repeated auger-borings from the floor of the trench.

The roadway follows a slight indentation in the scarp, and this gulley is evidently either the cause or the result of the foundered nature of the slope. The return journey down the hill was made by a footpath that keeps to a slight spur. Here there is scarcely any hill-creep, and the succession of the strata is manifest. On this occasion it was unusually clear, for an observer from a little distance could locate the outcrops of clay, sand and chalk by the attitude of members as they descended. Only on the all-too-thin outcrops of sand was there any approach to dignity.

Tea was taken on the relatively secure foothold provided by the Reading Basement Bed, and before the negotiation of the succeeding chalk slope Dr. Dix expressed the thanks of the party to the Director for an excursion modified, but in no sense ruined, by the weather.

FIELD MEETING—A WALK IN WEST LONDON.

Wednesday, 16th May, 1945.

Report by the Director : C. N. Bromehead, B.A., F.G.S.

THE party, numbering nearly forty members and friends, exclusive of gate-crashers from the general public, assembled at 7 p.m. in the Embankment Gardens, Charing Cross. The Director pointed out that, as geologists, they were meeting in the river, since geologists ignore made-ground ; the natural position of the river-bank was marked by the Watergate of York House, which was just beginning to emerge from its war-time protection of sandbags and boards. A little farther east, much ground was reclaimed in 1767, when the bank was along the present Tallis Street ; in the city area reclamation probably began in Roman times. Consequently the slope from water-level to the present Strand and Fleet Street was formerly much steeper than it now appears : the Strand runs along the margin of the Middle or Taplow gravel terrace, where this has been cut into by the river in its northward sweep. The first of the great houses off the Strand facing the river was the Savoy, built in 1248 A.D. But the river remained the chief highway, and in 1355 it is recorded that the road from London to Charing and Westminster was impassable on account of mud and bushes.

In 1691 the York House Waterworks were erected at the foot of Villiers Street. These pumped water direct from the Thames to the top of a pressure tower, and at one time supplied 2,700 houses between Piccadilly and Covent Garden ; they were of interest in the history of engineering, since they employed a Savory steam-engine, which was replaced in 1720 by one of Newcomens' [**1***]. A view showing the tower, which looks like a church-spire, the river lapping the Watergate steps and a boat on the site where the party was standing is given in Chambers' *Book of Days* under May 26th, for the reason that Pepys, while President of the Royal Society, resided in a house close by ; more interesting to geologists is the fact, of which Mr. Templeman reminded the Director, that William Smith lived and wrote most of his works almost on the same spot.

The party then walked up Northumberland Avenue, once the course of a stream formed by springs near Piccadilly Circus and Leicester Square (see 6-in. Geological Map) ; in its mouth at the bottom of Craven Street were wharfs for coal barges. Passing the Admiralty, from the foundations of which arctic plants were first recorded in the flood-plain gravels [**2**], a halt was made in St. James's Park opposite Carlton Terrace. The difficulties of geological mapping in London were pointed out; building operations have largely obscured the natural features, but records show that between Piccadilly and Jermyn Street the surface of the London Clay is at 55 ft. O.D., on the north side of Pall Mall it is at 3 ft. O.D., the solid shelf between the Middle and Low Terrace being thus clearly defined.

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* For List of References see p. 234.

At the Victoria Memorial, some particulars were given of the Tyburn or Aye-brook, one of London's now "buried" streams [3]; rising from springs at the base of the Bagshot Sands and in the sandy parts of the Claygate Beds near Belsize Park, Hampstead, it passed through St. Mary-le-burn, along the dip in Piccadilly and the Green Park to the courtyard of the Palace and then divided, one branch continuing southward under Abbot's Bridge (in Victoria Street, a name now lost) to the Thames at Vauxhall Bridge; the other passed along Buckingham Gate and again divided on either side of the little gravel-island of Thorney, the nucleus of Westminster. The courses of the streams, with the minimum of human interference, are shown on the geological maps, but many diversions and straightenings took place at various periods. The northernmost outlet was the Mersfleet, the word "fleet" meaning a creek made navigable for boats. Some historical notes illustrating the history of the marshland and the gravel island were given.

At the north-east corner of the Green Park, the site of a former reservoir was pointed out; this received raw Thames water pumped from Chelsea for the supply of the St. James's district; a print of 1808, reproduced in [4], shows a dog being given a swim in this drinking water; later, the reservoir was covered, but filter-beds for London water supply were not introduced until 1829.

Crossing the valley of the Tyburn, a halt was made near the old conduit house 250 yards west of Hyde Park Corner; the site of an important brickworks behind St. George's Hospital was pointed out and part of Sir John Hill's description was quoted [5]. The grey bricks made were said to be of excellent quality, but the clay needed three times as much working as the loam (valley brickearth) ordinarily used; Hill mentions that the owner of the pit was trying the experiment of mixing ashes with the clay, the familiar London Stock bricks being the result.

At the foot of the Serpentine, made for Queen Caroline in 1730 by damming the Westbourne, the course of that stream was briefly described from its source at Hampstead and Kilburn, across the Oxford Road at Baynard's Watering (Bayswater), under Knight's Bridge to Sloane Square, where the pipe now carrying the water can be seen crossing the underground railway above the station platform, and so to the Thames. Westbourne Street, south-east of Sloane Square, which until a few years ago commemorated the course of the stream, has now been renamed Bourne Street. It is recorded that in the year 1141, the ciitzens of London met Queen Matilda at Knightsbridge "according to custom"; evidently the stream then marked the boundary of outer London; many of the courses of buried streams are perpetuated as parish boundaries.

At the northern end of the dam is a pedestal recording the gift by St. Edward the Confessor of springs to supply the monks of Westminster by means of a conduit; they were situated at the edge of the Middle Terrace gravel, where the Westbourne cut through the London Clay. Here the Director gave a short account of the conduit system, mentioning that the first springs taken over for the supply of public conduits for London were on the banks of the Tyburn, in 1234 [**6**], while those of the Westbourne in Paddington were added in 1437; fuller accounts can be found in references [**4**], [**7**] and [**8**] and of the history of London water supply in general in [**9**] and [**10**]. From 1861 water for the Serpentine was obtained from a well at the head, which reached the Chalk at a depth of 317 ft. and had a total depth of 321 ft. Figures for the water-level in this well, taken from [**10**], serve to illustrate one of the present-day problems of London water supply: in 1861 the rest-level was —45 ft. O.D., in 1912 —141 ft. O.D., and the well is now abandoned; over-pumping of the chalk water has caused a drop in level of almost 100 ft. in 50 years.

On the way to Kensington Gardens, the great excavation for sand and gravel, made in the first days of the war for filling sandbags, was passed; it has now been filled in with rubble and levelled over. A very great saving was effected by digging supplies as near as possible to districts where they were required; the pits in the flood-plain were better than those in the middle terrace, the proportion of sand to stone being higher; from the Hyde Park site material was extracted at the rate of 430 cubic yards per hour, and within the County of London a quarter of a million cubic yards were used in the first month of the war.

At the boundary of the Gardens, mention was made of the old Kensington Gravel Pits near Notting Hill Gate, of the "hump" in the Broad Walk, which marks the outcrop of the London Clay between the terraces, and of St. Govor's well just to the east; this last was a spring, said to be somewhat purgative, given out at the edge of the gravel and adapted, by excavation and masonry, for filling vessels, a typical "Tite": that word is still in use in Oxfordshire, but obsolete elsewhere, though surviving in place-names in Buckinghamshire, Surrey, Gloucestershire and probably other counties.

Before the party broke up the Director read extracts from a manuscript compiled by an anonymous member of the Association, purporting to be an account of the London Excursion in 1725 by the Director, Dr. John Woodward: while the excursion was, of course, imaginary, all the pits visited and the objects found thereat are as listed in Woodward's catalogues [**11, 12, 13**] and as far as possible are described in his own words; the sites of pits can mostly be found in Rocque's maps [**14, 15**]. Anyone specially interested either in London or in the history of British Geology should read the report, which is preserved in the Association's library.

REFERENCES.

1. Cronin, H. F. In discussion of [4].
2. Abbott, W. J. L. 1892. *Proc. Geol. Assoc.*, pp. 346-356.
3. Head, J. G. 1907-8. *Auctioneers' Inst.*, pp. 20-46.
4. Bromehead, C. E. N. 1942. *Geog. Journ.*, xcix, pp. 142-151 and 183-196.
5. Hill, J. 1748. *General Natural History*, vol. i, " The History of Fossils," London : (Coloured plates, " Fossils" in the old sense of Minerals, Rocks, etc., with appendix on " Extraneous Fossils," i.e. organic remains, pl. 6-12).
6. Morley-Davies, A. 1907. *Trans. Middlesex Arch. Soc.*, N.S. ii, pp. 9-59.
7. Bromehead, C. E. N. 1922. *Geog. Journ.*, lx, pp. 125-135.
8. ——— and C. P. Chatwin. 1922. " Geology of the London District," *Mem. Geol. Surv.*, 2nd ed.
9. Matthews, W. 1835. *Hydraulia—an Historical and Descriptive Account of the Water Works of London.* London.
10. Buchan, S. 1938. Water Supply of the County of London from Underground Sources. *Mem. Geol. Surv.*
11. Woodward, J. 1728. *Fossils of all kinds digested into a method.* London.
12. ———. *Catalogue of Additional English Native Fossils.* London, 1728.
13. ———. *Natural History of Fossils of England.* Part I : Fossils that are Real and Natural. Part II : Fossils that are Extraneous. London. 1729.
14. Rocque, J. Survey of London, 1746. Scale 5¼ in. to 1 mile.
15. ———. Plan of London and Westminster. 1746. Scale, 26in. to 1 mile

Both these maps have been reproduced by the London Topographical Society. A map on a reduced scale, based on [5] is given in Besant, W., "London in the 18th Century," 1902.

GEOLOGICAL SURVEY MAPS.

Six-inch, colour-printed, London, N. IV S.E., V.S.W.

FIELD MEETING AT MERSTHAM AND REDHILL.

Saturday, 26th May, 1945.

Report by the Director : S. E. Coomber, A.R.S.M., B.Sc., D.I.C.

THE Director met a party of 26 members at Merstham Station at 2.20 p.m. and first outlined the programme of the meeting, the object of which was to give members an opportunity of examining excellent exposures of the Folkestone and the Sandgate Beds.

From Merstham Station the route followed Nutfield Road and Battlebridge Lane into Frenches Road. The site of the Nursery Pit in which the junction of Folkestone Beds and Gault has been recorded [**1**] was pointed out when passing the ruins of All Saints' Church. The party turned from Frenches Road into the property of the Standard Brick Co., where they were met by Mr. H. R. Taylor, manager and director, who very kindly showed them over the pits in the Folkestone Beds and explained the method of working. The sands here correspond with Gossling's " Silver Sands " division of the Folkestone [**1**]. In parts they are very pure and are used as glass sand ; the less pure variety is made into sand-lime bricks. At its southern end the pit is some 50 feet deep and shows an excellent section of fine-grained, clean, cross-bedded sand traversed by irregular veins of " hard-pan " (carstone).

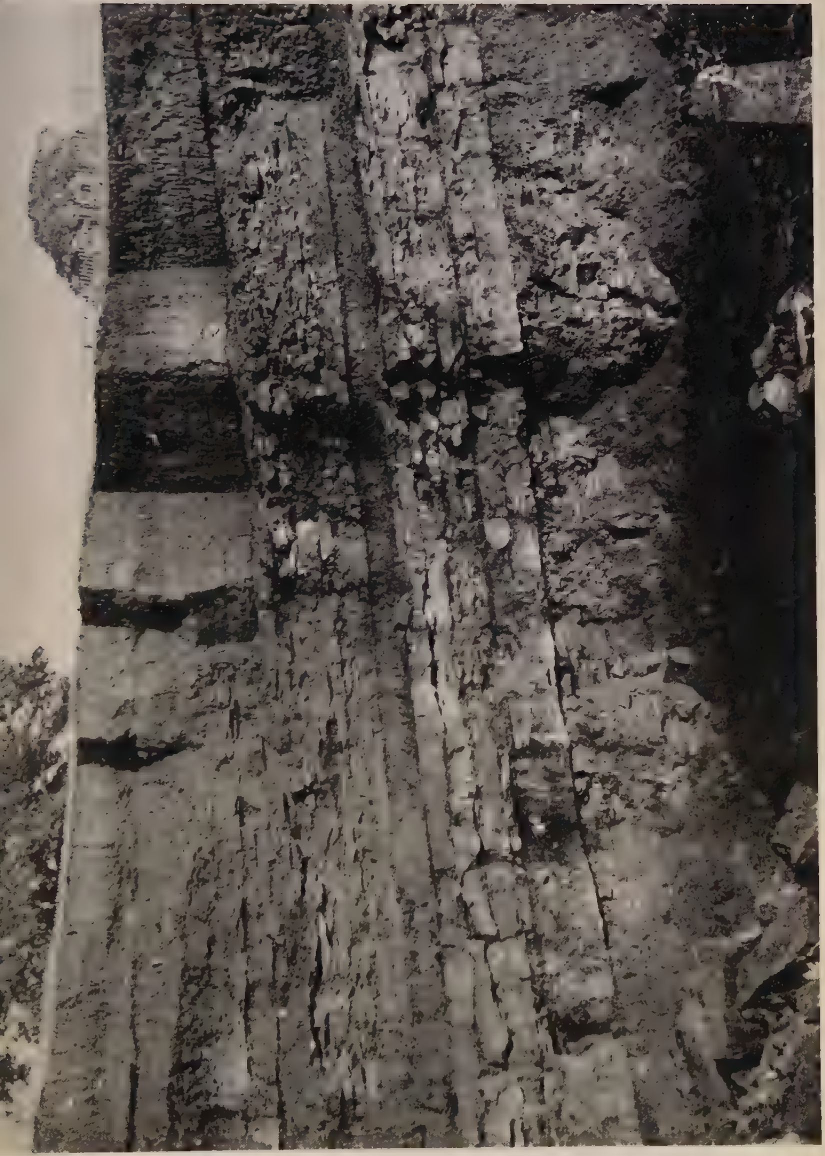
The ground between South Merstham and Redhill is flat and covered with brickearth which has been worked fairly extensively in the past. The Standard Brick Co.'s pits are located amidst some of these old workings, the grass-covered outlines of which were seen. The brickearth here appeared to be approximately 6 feet thick. Owing to this cover of brickearth, exposures of the " solid " geology are found only in quarries, and therefore the party, after leaving the Standard Brick Co.'s property, proceeded straight to the Copyhold Quarry of the Fullers' Earth Union, Ltd., 1,000 yards to the south. The working face of the quarry is about 200 yards long in a direction slightly oblique to the strike. At the western end the quarry is about 70 feet deep and the section shows 20 feet of basal Folkestone Beds, with the coarse, pebbly development described by Gossling [**1**] resting on loamy, glauconitic sands of the Sandgate Beds. At the eastern end the quarry is only about 30 feet deep, with no Folkestone Beds, and here the party examined the Sandgate section in some detail. At the base is a 13 feet thick seam of fuller's earth, and this is succeeded by massive calcareous sandstones, which are interbedded with other thin seams of fuller's earth, the whole forming the Nutfield facies of the Sandgate Beds. The presence of large nodules in the main seam of fuller's earth and the somewhat unusual association of quartz and barytes in these nodules excited some interest and comment, but no definite contributions to the subject emerged.

From Copyhold Quarry the party proceeded 400 yards up the dip slope to another small quarry in Sandgate Beds, where the beginning of a small fault was seen ; the beds have now been excavated and the section has disappeared. After leaving this quarry a hearty vote of thanks was accorded to the Director, and the party proceeded by divers routes to Redhill Station.

Thanks are tendered to Mr. H. R. Taylor, of the Standard Brick Co., and to Col. W. T. Raikes, managing director of the Fullers' Earth Union, Ltd., for kindly allowing the party to visit their properties.

REFERENCES.

1. Gossling, F. The Geology of the Country around Reigate. *Proc. Geol. Assoc.*, vol. xl, pp. 197-259.



Copyhold Quarry (East End), Redhill, Surrey, Showing Main Seam of Fuller's Earth, at Base.

[To face p. 236.

FIELD MEETING AT POLESWORTH AND DORDON, WARWICKSHIRE.

Saturday, 2nd June, 1945.

Report by the Director : G. H. Mitchell, D.Sc., F.G.S.

ABOUT two dozen members and friends assembled in showery weather at Polesworth Station at 11.30 a.m. They first noticed the escarpment made by the basal beds of the New Red Sandstone and the course of the important Polesworth Fault affecting the Coal Measures.

The party then walked through Polesworth village to the Opencast Coal Site at Church Hill, Dordon. Here the upward succession of the principal coals near the base of the Warwickshire Coal Measures was seen, including the Bench, Deep, Deep Rider, Seven Feet and Thin seams. A number of faults were demonstrated, and the repetition of the seams noticed. Attention was directed to the marine shales above the Thin Coal, but conditions were not good for collecting. At the southern end of the site a considerable length of Bench Coal was bared and the effects of old workings seen. The modern opencast technique, using " scrapers " and " diggers," interested the party.

On the way to the Orchard Site about a mile to the south, a short pause was made for lunch. Following this a considerable time was spent examining the information bearing on the Dordon Anticline. A start was made on the eastern side of the site, where the Bench, Deep and Deep Rider coals and their accompanying measures were seen dipping eastwards, and at one place were overlain unconformably by the basal sandstone of the New Red Sandstone. Some of the members braved a severe rainstorm to collect " mussels " and other fossils from the roof shales of the Deep Rider Coal, while others took temporary shelter ; but the whole party then disregarded the weather to cross the old workings, now infilled, to the western limb of the anticline. Here the open workings provided an excellent section of the westerly upper coals and measures from the Bench Coal up to the Seven Feet and the accompanying faulting attracted much attention. The opportunity was taken to examine the large " walking dragline " in course of erection for use in future workings. The party was then entertained to a high tea by Messrs. Sir Lindsay Parkinson & Co., and their appreciation was voiced, amid applause, by Prof. L. J. Wills.

The next section visited was the Baddesley Wood Site, where excellent landslips induced by the workings were examined and washouts in the Coal Measures affecting the Deep Rider Coal were followed. A further heavy rainstorm assailed the party on its journey to Grendon Wood. The weather improved on arrival at the trial trench, which, though somewhat slipped, showed the whole of the Warwickshire Coal Measures from above the Four Feet Coal down to the Bench Coal. Professor Wills then closed the meeting with a few remarks and members returned to Atherstone in time for the evening trains.

FIELD MEETING AT WELLINGTON, SHROPSHIRE.

1st and 2nd September, 1945.

Report by the Directors: R. W. Pocock, D.Sc., F.G.S., and G. H. Mitchell, D.Sc., F.G.S.

Saturday, 1st September, 1945.

A PARTY of 28 members and friends assembled at the Charlton Arms at 9.30 a.m., and took the road to Steeraway. At the Watling Street Dr. Pocock made a few introductory remarks on the geography and general geology of the district. Crossing the golf course the features made by glacial drift were noticed and the outcrops of the Cambrian rocks between the Ercall and Steeraway were pointed out.

At Steeraway some time was spent examining the old Carboniferous Limestone quarries and fossils were collected from the tips, while some members investigated the evidence for the presence of basalt below the limestone in the woods west of the quarries. The basal Coal Measures sandstone was crossed on the path to Huntington Heath. On the heath the extensive opencast coal workings were examined, and Dr. Mitchell explained the sequence and demonstrated all stages in the winning of outcrop coal. Owing to the heavy rain of the previous day the conditions were muddy and members found the going heavy on the working sites. After a short interval for lunch, the party next visited the Willow Moor opencast coal site lying some 600 yards south-west of Huntington. A good section of the Clod, Randles, Two Foot and Clunch coals was seen despite the sea of mud which covered the floor of the workings.

At Little Wenlock, workings in the basalt were visited, and a trial trench at Coalmoor yielded *Lingula* from the shales above the New Mine Coal and also provided a section of measures, including the Big Flint, Yard and Double Coals. From Coalmoor the party turned eastwards in heavy rain to the Coalmoor Basalt Company's quarry at Lydebrook Cottage, where they were welcomed by Mr. Knight, the quarry manager, and after viewing the basalt, which has a thick zone of " weathering " at the top and is overlain by boulder clay, they continued to Horsehay. At the Doseley Quarries of Basalts Ltd. the party was met by the manager, Mr. N. G. Mulroy. The Lower Carboniferous age and the extrusive character of the basalt were demonstrated, and there was a lively discussion as to the origin and direction of the columnar jointing and of the masses of pebbly sandstone and shale incorporated in the lower part of the flow.

From Doseley most of the party elected to walk back to Wellington, but several members made a short detour to visit the

Wellington Road opencast coal site, half a mile south-west of Lawley Bank Station. At this site, workings in the New Mine Coal were seen and the effects of the Ketley Fault were well displayed in trial excavations. *Carbonicolae* were collected from shales above the Top Coal.

Sunday, 2nd September, 1945.

The party left the Charlton Arms at 9.30, taking the road to the Ercall. The old quarries in the pink Ercall granophyre provided good specimens of this interesting rock. At the entrance to Buckatree Glen, Dr. Pocock pointed out the position of the Wrekin Fault and the presence of Cambrian quartzite on its north-west side. In the glen the quarry in Uriconian rhyolite was examined and flow-banded and nodular types of rhyolites were observed. At the eastern end of the glen a large quarry provided a fine section in the Wrekin quartzite showing bands of breccia made up largely of fragments of Uriconian rhyolites. Mr. Mulroy then led the way through the woods to Maddocks Hill, where the Camptonite intrusion in Shineton Shales is being quarried. The shales are exposed at several points and a hunt for *Dictyonema* was soon rewarded by some excellent specimens.

A short distance up the lane the outcrop of the Lydebrook Sandstone at the base of the Lower Carboniferous was indicated, and the overlying anygdaloidal basalt was seen in the banks of the lane. The line of old workings in the Carboniferous Limestone above the basalt was also pointed out. After lunch at Maddocks Hill the party descended the road to the Forest Glen and inspected the fine section of Uriconian pyroclastic rocks in the quarry at the Pavilion, where particular attention was drawn to a very coarse conglomerate made up of pebbles and well-rounded boulders of rhyolite, vein quartz, etc., up to a foot or more in length in a matrix mainly of vesicular andesite fragments.

From the Forest Glen the party climbed the Wrekin (1,335 ft.), passing over the outcrops of the north-eastern pyroclastic series and the thick sequence of the summit rhyolites. The view from the summit was not extensive, owing to poor visibility, but the nearer landmarks were pointed out and, after the directors had been thanked by Professor Simpson on behalf of the party, the members made their way down to the Forest Glen and thence to Wellington.

REFERENCES.

Pocock, R. W. and T. H. Whitehead. 1935. British Regional Geology. The Welsh Borderland. *Mem. Geol. Surv.*

————. 1938. Shrewsbury District. *Mem Geol. Surv.*

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